

Beaver Creek
627.83 Reservoir Dam,
Uliberd Hill County,
1981 Montana, MT. -510

1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

23

BEAVER CREEK RESERVOIR DAM HILL COUNTY, MONTANA MT. - 510

PREPARED FOR:

STATE DOCUMENTS COLLECTION

MAR 14 1991

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

HILL COUNTY COMMISSIONERS
(OWNERS - OPERATORS)

PREPARED BY:



Christian, Spring, Stelbach & Associates
Bozeman, Montana

Assisted By:

Northern Testing Labs, Inc.
Great Falls, Montana

February 1981

PLEASE RETURN 

Seattle District
United States
Army Corps of Engineers

S 627.83 U11bcd 1981 c.1
Beaver Creek Reservoir Dam, Hill County,

S 627.83 U11bcd 1981 c.1
Beaver Creek Reservoir Dam, Hill County,



3 0864 00071327 4

S Beaver Creek
627.83 Reservoir Dam,
U11bcd Hill County,
1981 Montana, MT. -510

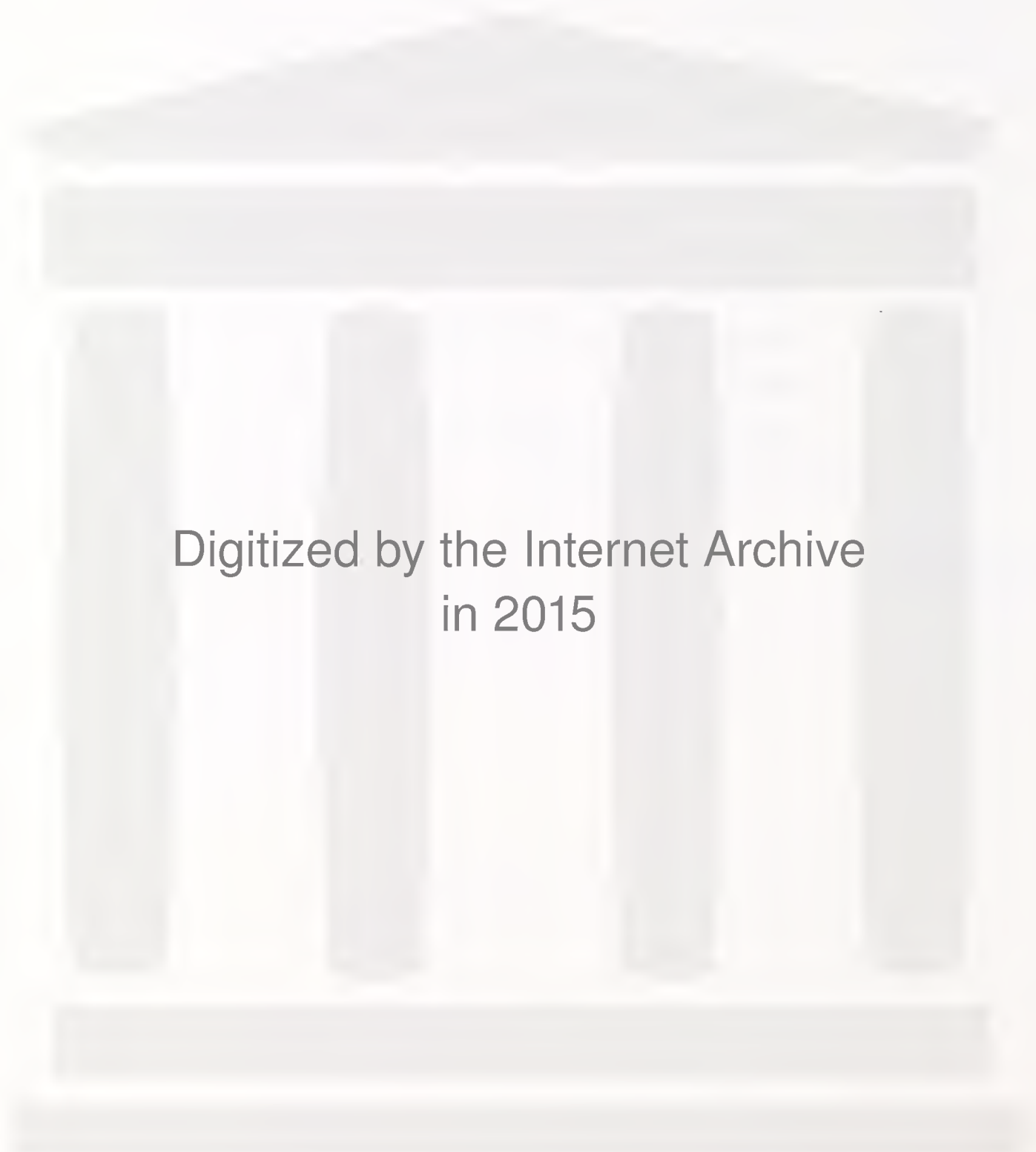
[illegible]

TABLE OF CONTENTS

<u>Paragraph</u>		<u>Page</u>
	Executive Summary	i
	Pertinent Data	iv
CHAPTER 1 - BACKGROUND		1
1.1	INTRODUCTION	1
1.1.1	Authority and Scope	1
1.1.2	Purpose	2
1.1.3	Inspection	2
1.2	DESCRIPTION OF PROJECT	3
1.2.1	General	3
1.2.2	Regional Geology - Beaver Creek	4
1.2.3	Seismicity	4
1.2.4	Site Geology	4
1.2.5	Design and Construction History	5
CHAPTER 2 - INSPECTION AND RECORDS EVALUATION		6
2.1	HYDRAULICS AND STRUCTURES	6
2.1.1	Spillways	6
2.1.2	Outlet Works	7
2.1.3	Freeboard	8
2.2	HYDROLOGY	8
2.2.1	Physiography and Climatology	8
2.2.2	Reservoir Storage and Spillway Discharge	8
2.2.3	Estimated Probable Maximum Flood	8
2.2.4	Flood Routing	9
2.3	GEOTECHNICAL EVALUATION	10
2.3.1	Dam Embankment	10
2.3.2	Foundation Conditions, Seepage and Drainage	11
2.3.3	Stability	11
2.4	PROJECT OPERATIONS AND MAINTENANCE	13
2.4.1	Dam	13
2.4.2	Reservoir	13
2.4.3	Warning Plan	13

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Page</u>
CHAPTER 3 - FINDINGS AND RECOMMENDATIONS	14
3.1 FINDINGS	14
3.1.1 Size, Hazard Classification, and Dam Safety Evaluation	14
3.1.2 Spillways	14
3.1.3 Outlet Works	15
3.1.4 Reservoir Storage and Spillway Discharge	15
3.1.5 Embankment Dam	15
3.1.6 Geotechnics - Site Geology	15
3.1.7 Stability	16
3.1.8 Operations and Maintenance	16
3.2 RECOMMENDATIONS	16
REFERENCES	18



Digitized by the Internet Archive
in 2015

<https://archive.org/details/beavercreekreser1981chri>

PHOTOS

(Bound at End of Text)

1. General Upstream Slope View
2. Erosion Rill on Downstream Slope
3. Outlet for Drain From Left Abutment
4. SCS Boring under Artesian Head
5. Joint Separation of Chute Walls
6. Drain Pipe (Sheared) behind Spillway Wall
7. Chute Spillway
8. Irrigation Outlet
9. Downstream View
10. Top of Pressure Chamber

PLATES

BEAVER CREEK RESERVOIR

- Plate 1. Vicinity Map
- Plate 2. Beaver Creek Drainage (Photo)
- Plate 3. Beaver Creek Watershed
- Plate 4. Geologic Section
- Plate 5. Chimney Drain and Embankment Drainage
- Plate 6. Outlet Conduit and Dam Embankment
- Plate 7A. Principal Spillway
- Plate 7B. Principal Spillway
- Plate 8. Emergency Spillway
- Plate 9. Outlet Works Discharge Rating
- Plate 10. Combined Spillway Discharge Rating

EXECUTIVE SUMMARY

Personnel of Christian, Spring, Sielbach & Associates, principal contractor, and Northern Testing Laboratories, Inc., subcontractor, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC) and with representation from the Hill County Commissioners, the MDNRC, and the U.S.D.A., Soil Conservation Service (SCS), inspected Beaver Creek Reservoir Dam on 19 and 20 June, 1979 under authority of Public Law 92-367. The project is located in the West one-half of Section 25, Township 31 North, Range 15 East, M.P.M., on Beaver Creek within the boundaries of Beaver Creek Park, Hill County, Montana, about 13 miles south of the City of Havre. Bearpaw Lake is located on Beaver Creek about 7 miles upstream from Beaver Creek Reservoir. East Fork Reservoir Dam is located about 11 miles upstream from Bearpaw Lake.

This report was compiled from information obtained during the onsite inspection, review of design data, construction plans, explorations and analysis of available hydrologic information. The Probable Maximum Flood was developed using methods and procedures outlined by the Corps of Engineers. Flood routing was accomplished using the HEC-1 program. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

Findings and Evaluations

Beaver Creek Dam was constructed in 1973-1974 under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress). The dam is owned and operated by the Hill County Commissioners. The project was planned as a multi-purpose flood prevention, irrigation, recreation and fish and wildlife storage facility. Campgrounds are located on the east shore of the lake.

The 108-foot high dam impounds 8700 acre-feet of water at top of dam elevation 3102.5 feet MSL. Lake levels are controlled by manual manipulation of gated outlet works. The principal spillway is an uncontrolled

18-foot wide concrete chute with crest elevation at 3091.5 feet MSL. An earth emergency spillway with crest elevation 3097.5 feet MSL and a crest length of 650 feet provides for passage of flood flows. There is approximately 2430 acre-feet of surcharge storage available between the principal spillway crest and top of dam. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is large in size. The sudden failure of Beaver Creek Reservoir Dam would cause extensive property damage and could endanger many lives. Therefore, the project is classified as having a high (Category 1) downstream hazard potential.

The conclusions on probable damage are based on the field visit and judgment. No dam breach analysis or routing of a dam break hydrograph was made for the downstream area. In accordance with inspection guidelines the recommended spillway design flood (SDF) for a large sized project with high downstream hazard potential is 100 percent of the Probable Maximum Flood (PMF).

The estimated PMF developed for this study resulted from a general storm Probable Maximum Precipitation (PMP). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The resultant PMF has an estimated volume of 79,300 acre-feet and a peak flow of 115,700 c.f.s. The combined discharge capacity of the principal and emergency spillways with the reservoir at dam crest elevation 3102.5 feet MSL is 17,280 c.f.s. Routing of the estimated PMF indicates that the dam is overtopped when 24% of the total flood volume enters the reservoir. Routings of lesser hypothetical floods made by applying percentages to the PMF ordinates showed that a flood corresponding to 19 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam. Based on the reconnaissance level investigations, the project is incapable of handling a flood having one-half the PMF ordinates without overtopping and causing the dam to fail. In accordance with recommended guidelines Beaver Creek Reservoir Dam is considered unsafe (non-emergency) until recommended actions are completed.

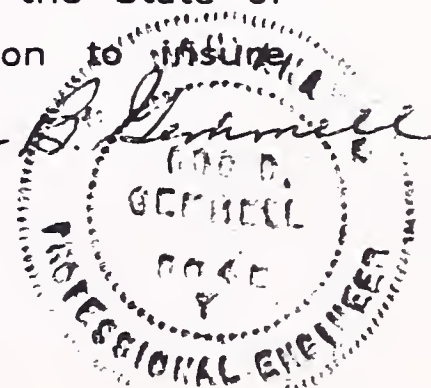
The visual inspection showed the dam and appurtenant structures to be performing well, with no visual signs of structural distress. Seepage that appeared downstream on the left abutment at first filling of the reservoir has been drained, and the seep area appears stabilized. A review of design data and stability analysis employed by the SCS for design of embankment slopes, drainage systems, and foundation treatment appear to be adequate in controlling seepage. The downstream slopes appear to be free of damaging seepage, however, the factor of safety obtained in the stability analysis performed by SCS assumed that the chimney drain was fully effective. Since no instrumentation was installed this assumption could not be confirmed.

Recommendations

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of the report recommendations is to maintain or improve project safety without decreasing this existing flood protection. A downstream warning plan for use in the event of impending dam failure must be developed, tested and placed in action. Coordinate the warning plan with the plan developed for Bearpaw Lake Dam. Inspect the inside of the pressure chamber housing gates, irrigation outlet conduit, low level outlet conduit, and gates and repair as required. Repair erosion rills on downstream slope and groin area of downstream right abutment. Install piezometers and monitor to more accurately determine the effectiveness of the chimney drain and pore pressure distributions within the embankment. Use this data to update stability analysis and modify the dam if required. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Studies should include a possible overtopping and breach analysis of upstream East Fork and Bearpaw Lake Dams. Modify the project as studies indicate. Conduct inspections of Beaver Creek Reservoir Dam at least every 5 years by qualified engineers experienced in earth dam design, construction, operation, and maintenance. Prior to performing engineering studies, and possible remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Bob B. Gemmell, P.E.

Montana No. 504E



PERTINENT DATA

1. General

Federal ID No.	MT-510
Owner	Hill County, MT
Operator	Hill County, MT
Date Constructed	1973-74
Purpose	Flood Control, Irrigation, Recreation, and Fish & Wildlife
Location	W $\frac{1}{2}$ Section 25, T31N, R15E, MPM
Watershed	Beaver Creek Tributary to Milk River
Downstream Hazard Potential	High (Category 1)
USGS Quadrangle-	Shambo

2. Reservoir

Surface Area at Principal (Chute)	
Spillway Crest	185 acres
Drainage Area	79 square miles
Storage at Principal Spillway Crest (elevation 3091.5 feet MSL)	6270 acre-feet
Storage at Dam Crest (elevation 3102.5 feet MSL)	8700 acre-feet
Surcharge Storage (Principal Spillway Crest to Dam Crest)	2430 acre-feet
Surcharge Storage (Emergency Spillway to Dam Crest)	1200 acre-feet

3. Principal Spillway

Type	Uncontrolled concrete chute
Crest Elevation	3091.5 feet MSL
Crest Length	18 feet
Capacity with Reservoir at emergency spillway crest (Elevation 3097.5 feet MSL)	820 cfs
Capacity with reservoir at top of dam (elevation 3102.5 feet MSL)	2030 cfs

PERTINENT DATA

Continued

4. Emergency Spillway

Type	Uncontrolled, vegetated earth
Crest Elevation	3097.5 feet MSL
Crest Length	650 feet
Spillway Capacity with Reservoir at top of dam (elevation 3102.5 feet MSL)	15,250 cfs

5. Irrigation Outlet/Low Level Drawdown

Inlet (R.C. Monolith)	4'-6" X 4'-6" X 32 feet high
Drawdown Conduit	30-inch-diameter steel
Drawdown Conduit Length	105 feet
Outlet Conduit	30-inch-diameter reinforced concrete

5. Irrigation Outlet/Low Level Drawdown (Continued)

Inlet Gate Valve-w/hydraulic lift control	30-inch-diameter slide gate
R.C. Pressure Chamber w/2-Gate valves at outlet end of conduit (mechanical gate hoists)	10-inch-diameter slide gate 30-inch-diameter slide gate
Capacity with Reservoir at Principal Spillway Crest (Elevation 3091.5 feet MSL)	135 cfs

PERTINENT DATA

Continued

6. Dam

Type	Compacted Earth Embankment
Length	2855 feet
Crest Width	33 feet
Crest Elevation	3102.5 feet MSL
Hydraulic Height (crest to toe)	108 feet
Upstream Slope	Varies 1V on 2.5H to 4H, benched @ 20 foot-vertical intervals
Downstream Slope	Varies 1V on 2.5H to 3.5H, benched @ 30 foot-vertical intervals with 10' berm

CHAPTER 1 BACKGROUND

1.1 INTRODUCTION

1.1.2 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Beaver Creek Reservoir Dam, owned by Hill County, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections on non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phase study procedure for investigation and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

- (1) a limited investigation to assess the general safety condition of the dam.
- (2) based upon an evaluation of the available data and a visual inspection.
- (3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
- (4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analysis.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engi-

neering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership and operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current physical and operational conditions of the dam and appurtenances; and to determine if emergency measures and/or additional studies, investigations, and analyses are needed, so that corrections can be made in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a review of engineering data and records pertinent to the original design and construction of Beaver Creek Reservoir Dam, and a visual inspection of the project. Engineering data and records including design reports, hydrologic and hydraulic studies were reviewed at the state office of the Soil Conservation Service at Bozeman, Montana. The Soil Conservation Service provided planning and engineering installation services for the project. Inspection procedures and criteria were those established by the Recommended Guidelines for the Safety Inspection of Dams (Ref. 1) and as supplemented in the contract for Professional Personal Services for Dam Safety Investigations Pursuant to Public Law 92-367 National Dam Safety Program.

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates and Northern Testing Laboratories, Inc., subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA-	Bob B. Gemmell, Engineer, Team Leader
	Kent D. Brewer, Structural Engineer
	Alfred Cunningham, Hydraulics/Hydrology (report only)
NTL-	Robert Gillespie, Geotechnical Engineer
	Bill Henning, Geologist

Other personnel present and participating in the field inspection include:

Glen McDonald, Montana Department of Natural Resources and Conservation
Larry Tegg, Montana Department of Natural Resources and Conservation
Joe Calder, Soil Conservation Service
Claude Windecker, Reservoir Operator, Havre Irrigation Co.
Hal Watson, District Conservationist, SCS, Havre, Montana.

This report has been reviewed by: Hill County Commissioners, USDA Soil Conservation Service, Hill County Soil Conservation District (SCD), and the State of Montana and their written comments are enclosed in Appendix A.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

a. Location, Owner, and Purpose.

Beaver Creek Reservoir is located on Beaver Creek within Beaver Creek Park in the West one-half of Section 25, Township 31 North, Range 15 East, M.P.M., in Hill County, Montana, approximately 13 miles south of Havre, Montana by road. (Plate 2). The dam was originally planned and constructed under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666), as amended. Sponsors for the project were:

Hill County Soil and Water Conservation District
Havre Irrigation Company
Hill County Commissioners

The dam is owned, operated and maintained by Hill County Commissioners. The project was planned as a multi-purpose flood prevention, irrigation, recreation, and fish and wildlife storage facility.

b. Description of Dam and Appurtenances.

Beaver Creek Reservoir Dam is a rolled earth-fill structure with a hydraulic height of 108 feet and a crest length of 2855 feet, including a low-fill dike embankment on top of the right (east) abutment. It has an uncontrolled principal (chute) spillway, located near center of the fill with a crest length of 18 feet and a vegetated earth emergency spillway located on the right abutment with a crest length of 650 feet. The dam impounds approximately 8700 acre-feet at dam crest elevation 3102.5 MSL which is 5.0 feet above emergency spillway crest elevation 3097.5 feet MSL, and approximately 6270 acre-feet at principal spillway crest elevation 3091.5 feet MSL. The drainage area is 79 square miles. A trailer parking area and camping facilities are located on the east shore at an elevation generally above the top of dam.

The combined irrigation and outlet works used for drawdown consists of a 30-inch diameter reinforced concrete pipe with gate control contained in a concrete pressure chamber at the outlet end. A guardian gate with hydraulic lift is located at the entrance to the 30-inch diameter conduit.

c. Hazard Potential

Based on visual reconnaissance and judgement, approximately 20 residences, a golf course, two highway crossings, and a railroad crossing could be affected by a sudden breach of the dam. On the basis of the recommended inspection guidelines, Beaver Creek Reservoir Dam size is large and the downstream hazard potential is high (Category 1). The conclusions on probable damage are not supported by a dam breach analysis to determine possible flood heights that would be attained in the areas downstream that could be affected by a sudden failure. More detailed hydrologic and hydraulic routing studies are needed to accurately determine the downstream hazard potential.

1.2.2 Regional Geology - Beaver Creek

The Bearpaw Mountains region contains a wide range of intrusive and extrusive mafic, subsilicic-alkalic to felsic, silicic-alkalic rocks of Eocene age.

The extrusive rocks are a wide assortment of flows and flow breccia, pyroclastic deposits and volcanic sediments. The intrusive rocks occur as dikes, sills, plugs, and stocks. These volcanic rocks consist of an irregular assortment and wide variety of mafic and felsic rocks and their intrusive equivalents. The mafic extrusive rocks exceed the felsic in volume.

"Regional sedimentation in the Bearpaw Mountains region continued from Paleozoic into early Eocene time and ceased with the deposition of channel boulders derived from the Rocky Mountains region to the southwest. Deformation interrupted sedimentation and was followed by erosion and by eruption of a great variety of intrusive and volcanic igneous rocks in the remaining part of the Eocene epoch. Deformation continued concurrently with igneous activity but probably ceased in late Eocene time with faulting of the mountainous area. Erosion during the remaining part of the Tertiary developed the present mountainous configuration and established a drainage pattern that was adjusted to the late Tertiary Missouri River system. A continental ice sheet advanced southeasterly across the northern half of the quadrangle in late Pleistocene time, abutted against the high terrain of Number One Mountain and Mount Reynolds, filled the lower stretches of the existing valleys with till, and covered with drift all the pediment surfaces and interstream area below about 4,200 feet in altitude. The present stream course is largely the result of consequent drainage on ground moraine, and locally, as along Beaver Creek, parts of preglacial valleys have been resurrected. Evidence for more than one ice sheet is not available. Postglacial dissection in some places exceeds 150 feet." /1/

The volcanic rocks exposed in the Bearpaw Mountains can be divided into a northern and southern field, with volcanic rocks in the area of Beaver Creek Dam constituting the central part of the northern field. After volcanism ceased, the rocks were faulted, with the volcanic piles being tilted. Total thicknesses of these volcanic rocks is greater than 10,000 feet.

1.2.3 Seismicity

The inspection guidelines (Ref. 1) Seismic Zoning Map of Contiguous States shows the Bearpaw Mountain Region between Zones 1 and 2 which are zones of minor earthquake damage. Maximum seismic events in this area are expected to be less than Richter Magnitude 5.0. According to the guidelines, associated ground surface accelerations on the order of 0.025 to 0.05g are anticipated.

1.2.4 Site Geology

A subsoil exploration program was performed by the Soil Conservation Service for foundation design of this dam. Boring logs, along with a

/1/ Preliminary Geologic Map of the Shambo Quadrangle, Bearpaw Mountains, Montana. Map 1-236 USGS.

visual inspection of the area, were used to prepare this site description. The dam was constructed in a narrow valley, formed by down cutting of the creek through the glacial till, and stopping when felsic volcanic agglomerate was encountered at the present valley floor. The abutments consist of dense, clayey till. The till is 50 feet plus in depth, and is underlain by Felsic volcanic agglomerate. Alluvial soils have been deposited to depths of from 0 to 15 feet in the creek channel and are resting on volcanic bedrock. Volcanic rock outcrops downstream from the dam on the south side of the creek. Both ends of the dam are tied to the glacial till. Alluvial materials have been removed in the stream channel and the dam is founded on the glacial till or bedrock. The irrigation outlet conduit and spillway outlet are founded on bedrock.

1.2.5 Design and Construction History

The project was planned under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 66 Stat. 666), as amended. The Watershed Work Plan (Ref. 2) was prepared by the Hill County Soil and Water Conservation District, the Havre Irrigation Company, and Hill County Commissioners, with assistance by U.S.D.A. Soil Conservation Service. Design and installation services were furnished by the Soil Conservation Service. Bid award was made by the contracting local organization in May, 1972 and construction of the dam was completed in March, 1974. The contracting local organization (Hill County Commissioners) completed rip-rap placement under force account in June, 1975. The reservoir was filled in the spring of 1974. A leak that developed on the downstream left abutment at first filling was repaired and drained to the irrigation outlet. Project design and construction records are on file in the Soil Conservation Service state office at Bozeman, Montana.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillways

a. Principal Spillway.

The principal spillway for Beaver Creek Reservoir is a reinforced concrete chute located near the center of the dam embankment. (Plate 7). The spillway crest length is 18 feet with the control section located at a point where the slope changes gradually to insure super critical flow downstream from the control section. Side wall height at the control section is 11 feet. Review of original design computations show that control remains at the spillway crest for all discharges. The elevation of the principal spillway crest is 3091.5 feet MSL. The discharge capacity of the principal spillway is 820 c.f.s. with reservoir at emergency spillway crest elevation 3097.5 feet MSL and 2030 c.f.s. with reservoir at dam crest elevation 3102.5 feet MSL. The spillway terminates in a hydraulic jump stilling basin energy dissipator. Discharge was computed for the 18-foot wide spillway by assuming a discharge coefficient of 3.1. A preliminary evaluation of the water surface profile when flowing at maximum capacity shows that the discharge is contained in the chute. Possible air entrainment or wave disturbances was not considered.

The field inspection of the principal spillway showed that in general its condition is excellent. There is evidence of minor movement, as indicated by wall joint separation. (Photo 5). Almost all chute floor slabs are cracked (macro to about 1/16-inch) at the midpoint, parallel to the chute walls. A survey at time of field investigation indicates that the spillway crest and adjoining sections may have settled about 0.47 feet, which is not considered excessive for this height of dam. There is no visible evidence of heave. Some staining at the slab joints indicates some seepage. The Soil Conservation Service is currently investigating this condition. A slope drain on the east side of the spillway through the side wall has broken at the outside face of the wall. (see Photo 6). Some minor vertical cracks were observed in side walls; however, there is no evidence of misalignment of the walls. The stilling basin chute blocks and baffle blocks appear in good condition. Water in the stilling basin prevented thorough inspection of end sill and floor. There is no evidence of deep scour downstream from the stilling basin that would threaten to undermine the chute spillway. (Photo 7). The inlet is protected by a floating log boom.

b. Emergency Spillway

The emergency spillway is excavated around the south and east of the right abutment, and is trapezoidal shaped with a bottom width of 650 feet and side slopes of 1V (vertical) on 3H (horizontal). In profile the spillway has a deep reverse grade approach, a 330-foot level section at elevation 3097.5 feet with control at the downstream end of the level section, and an exit channel of varying gradient. (see Plate 8). The emergency spillway is well covered with grasses and vegetation and shows no evidence of flows having occurred. With reservoir management of predictable snowmelt runoff and capacity of the lined chute spillway, it is anticipated that flows in the emergency spillway will be infrequent. With sub-critical velocities

in the 330-foot level section it is unlikely that breaching of the emergency spillway would occur.

Emergency spillway discharge capacity was computed by assuming critical depth at the downstream control of the level section. Backwater computations were made in the approach channel with a Manning's "n" of 0.030. The maximum discharge capacity of the emergency spillway with the reservoir at dam crest elevation 3102.5 feet MSL was estimated to be 15,250 c.f.s. The combined capacity of the emergency and principal spillways with reservoir at elevation 3102.5 feet was estimated to be 17,280 c.f.s. (Plate 10).

2.1.2. Outlet Works

The low level outlet is a 30-inch diameter steel pipe approximately 105 feet long. It connects to the bottom of a monolithic reinforced concrete riser with inside dimensions of 4'-6" x 4'-6" and a height of 32 feet. The riser is a wet well with a hydraulically operated guardian gate on the downstream side at the entrance to the irrigation outlet pipe. The irrigation outlet pipe downstream from the riser is a 30-inch diameter reinforced concrete pipe about 640 feet long resting on a reinforced concrete cradle. The pipe exits into a reinforced concrete pressure chamber which houses two control slide gates, 30-inch diameter and 10-inch diameter respectively. (Plate 6). The smaller gate is designed to release minimum stream flows when irrigation flows are not being released. The invert of the 30-inch diameter irrigation inlet is at elevation 3000.0 feet MSL and the invert of outlet is at 2998.5 feet MSL. The outlet has an impact basin which releases water to open channel flow. (Photo 8) As-built plans show that the cradle for the irrigation outlet pipe rests on bedrock, except for a short distance near the outlet end. A concrete support was installed to insure integrity of the pipe at this location. Examination of the inside of the pipe was not possible due to irrigation releases which could not be interrupted at the time of our visit.

The top of the pressure chamber gate housing at the outlet end had several hairline cracks in the concrete radiating from the steel manhole cover plate. The steel cover plate had minor rusting at the edges and around bolts. (Photo 10). The cover plate had apparently been field cut to fit the opening in the concrete. The impact basin at the outlet was in good condition and performing well hydraulically. There is some minor erosion of irrigation outlet channel banks and upstream from the Parshall measuring flume. A drop chute formed of cyclopean concrete (rock and mortar) has stabilized the irrigation channel where it drops into the spillway basin.

The upstream guardian gate located in the riser at the inlet to the 30-inch diameter reinforced concrete pipe is operated by hydraulic controls located on the upstream shoulder at top of dam. A slow leak in one of the operating cylinders allows the gate to slowly close. Mr. Windecker, Dam Tender, stated that it was necessary to raise the gate periodically to ensure full opening. The Owners and Soil Conservation Service's engineers are working with suppliers to correct this problem.

The theoretical maximum capacity of the outlet works with reservoir level at principal spillway crest elevation 3091.5 feet MSL and with gates

fully open is about 135 c.f.s. A comparison of measured discharge through the Parshall flume downstream from outlet works shows a measured discharge of 139 c.f.s. with lake elevation at 3091.5 feet MSL. This compares very favorably with the theoretical discharge.

2.1.3 Freeboard

Routings indicate that the dam overtops during the probable maximum flood (PMF; see Paragraph 2.2.4), therefore freeboard does not exist with the recommended spillway design flood. At the time of inspection the reservoir was at an elevation approximately 0.5 feet below the principal spillway crest elevation 3091.5 feet MSL. The vertical distance between the low point on dam crest and reservoir level at time of inspection was approximately 11.5 feet. The highest recorded lake levels are reported at elevation 3095.3 feet MSL 7.2 feet below the top of dam. The fetch for wind generated waves is over 6,000 feet and wave runup on the embankment is estimated to be less than 3 feet. Although the dam overtops during the PMF, the vertical distance of 11 feet is considered adequate to prevent overtopping by wind-generated waves during normal operation with reservoir elevation at or below the principal spillway crest.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The Beaver Creek drainage (Ref. 2) lies in north central Montana in the southeastern part of Hill County. (Plate 1). The drainage upstream from Beaver Creek Reservoir covers approximately 79 square miles, is approximately 25 miles long, and averages 3.5 miles in width. (Plate 2) Beaver Creek heads in the north central part of the Bearpaw Mountains at an elevation of 6942 feet and flows north to the Milk River about two miles west of the City of Havre at an elevation of about 2480 feet. Elevation of Beaver Creek Reservoir is about 3100 feet. Latitude at center of basin is 48°20' and longitude is 109°40'.

Average annual June through October precipitation at the Rocky Boy's permit No. 2 precipitation station (Elevation 5200 feet) is 12.34 inches, 60% of which occurs during May and June. An additional 4.5 inches of average April 1 snowpack water equivalent is observed bringing the total average annual precipitation at Rocky Boy to about 16.9 inches. Temperature variations are extreme in this region ranging from 100°F in summer to -40°F in winter months. The average annual frost-free period is 139 days with the last day of frost varying from late May to early June. Average annual lake evaporation is approximately 38 inches 80% of which occurs during May-October.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a storage of 6270 acre-feet at principal spillway crest, elevation 3091.5 feet MSL and 8700 acre-feet at top of dam, elevation 3102.5 feet MSL, providing approximately 2430 acre-feet of surcharge storage. The combined discharge of the principal spillway and emergency spillway with the reservoir at dam crest is about 17,280 c.f.s.

2.2.3 Estimated Probable Maximum Flood (PMF)

The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

The PMF for Beaver Creek Reservoir was developed using the HEC-1 Flood Hydrograph - Dam Safety Investigation Computer Program (Ref. 3). Primary program input consisted of the 72-hour probable maximum precipitation (PMP) which was obtained for the study site from Ref. 4. Generalized estimates of 10 square miles PMP for duration of 1, 6, and 24 hours were obtained from charts in Ref. 4 and subsequently adjusted based on drainage area size of 79 square miles. The 24-hour PMP was determined to be 16.28 inches. PMP values for 48- and 72-hour durations were estimated as 110% and 115% respectively for 48- and 72-hour PMP. A depth-duration curve was plotted from which one hour incremental rainfall values were determined and subsequently arranged in a critical sequence according to Ref. 5. Total precipitation for 72 hour period was 18.72 inches with a maximum hourly value of 5.63 inches.

The PMF hydrograph was developed based on a one-hour unit hydrograph (UHG) constructed using procedures outlined in Ref. 6. In calibrating the SCS unit hydrograph for input to HEC-1 a basin time of concentration of 4.0 hours was used along with an incremental storm duration of one hour. Combination of the critical PMP sequence with the UHG resulted in the PMF inflow hydrograph to Beaver Creek Reservoir. Because the reservoir surface area is small by comparison with drainage area (185 acres vs. 79 square miles) no attempt was made to consider precipitation falling on reservoir surface as a separate calculation. It was assumed that frozen soil conditions prevailed during the PMP resulting in an infiltration rate of zero.

The resulting estimated PMF peak inflow to Beaver Creek Reservoir was found to be 115,700 cfs while total inflow volume was 79,300 acre-feet.

NOTE: The drainage area of 79 square-miles encompasses the drainage area of 49 square miles contributing to Bearpaw Lake Dam and 3.2 square miles contributing to East Fork Reservoir Dam. Both dams are located upstream from Beaver Creek Dam on the Beaver Creek drainage.

2.2.4 Flood Routing

Routing of the estimated PMF hydrograph developed for this study through Beaver Creek Reservoir Dam project was accomplished by means of the computer program, HEC-1. (Ref. 3). Initial reservoir inflow was assumed to be 50 c.f.s. based on stream flow information published in Ref. 2. This value is a conservative estimate of spring snow melt runoff conditions. Initial water surface elevation in Beaver Creek Reservoir was assumed to be at principal spillway crest elevation 3091.5 feet MSL at onset of the PMF. Routing was accomplished using the modified puls method. Routings were made of lesser hypothetical floods to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates.

Routing studies indicate that:

- a. During the full PMF the dam would be overtopped when approximately 24 percent of the total flood volume enters the reservoir.
- b. A flood with a hydrograph corresponding to 19 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

NOTE: The routing did not include attenuation at Bearpaw Lake Dam, located 7 miles upstream, or a possible breach of Bearpaw Lake Dam that would occur during the estimated PMF developed for this investigation. It has been determined that Bearpaw Lake Dam overtops during the PMF when approximately 9 percent of the total flood volume enters Bearpaw Lake Reservoir, and a flood with a hydrograph corresponding to only 5 percent PMF ordinates is just controlled by that project. Further hydrologic studies and flood routings are needed to fully assess the impact of a possible breach of Bearpaw Lake dam on Beaver Creek Reservoir project.

2.3 GEOTECHNICAL EVALUATION

Beaver Creek Dam was designed by the Soil Conservation Service following a drilling and laboratory testing program. Data from both programs were made available to us and were used in this evaluation. Also, several geologic reconnaissance trips were made by the Soil Conservation Service personnel and the reports of their findings were incorporated in the final design.

2.3.1 Dam Embankment

The embankment is 108 feet high, with a crest width of 33 feet. The top of the dam serves as a roadway. Downstream slopes vary from 1V on 2H to 1V on 3.5H, with two intermediate benches on the slope. The effective slope with this configuration is slightly flatter than 1V on 3H.

The embankment was constructed using locally available glacial till as the major construction material. Riprap is mafic volcanic rock taken from local outcrops. As-built drawings show a chimney drain extending from Station 19+00 to Station 39+90, with the discharge into the irrigation outlet channel. See Plate No. 5. The drawings indicate that the collected flow from the chimney drain is carried by a pipe to the outlet but this could not be confirmed. Construction records, permeability and gradation test results for the chimney drain materials are on file in the Bozeman SCS office, but were not reviewed during this investigation. According to SCS records 109 permeability tests and 84 gradation tests of the drain fill material were made during construction as a basis of acceptance of the materials.

Project specifications call for embankment fill placement in uniform lifts of 6 to 9 inches and compaction to at least 95 percent of the maximum dry density as determined by ASTM D698. According to Soil Conservation Service personnel, the earthwork was tested at frequent intervals and met the specifications.

No instrumentation was installed in the embankment or appurtenant structures.

Visual observations indicate near-surface soils of the upstream embankment are silty to sandy clays, consistent with the glacial till borrow described on the Soil Conservation Service boring logs. Slope protection (photo 1) is adequate and is composed of gravel to boulder size mafic volcanic rock. Some deterioration of the larger sizes due to freeze-thaw action was noted. Riprap extends to within 5 feet of the crest (approximately elevation 3099). The unprotected areas are sparsely vegetated.

Near-surface soils on the downstream slope are silty to clayey sands with considerable organic material. Vegetation is heavy, with thick spike, western wheat and occasionally wild rose as the predominating species. There is no major erosion and only two minor rills (photo 2) between the middle bench and toe. There is also minor erosion due to foot traffic in the groin area of the right abutment. Several green areas were observed but no free water was noted.

2.3.2 Foundation Conditions, Seepage, and Drainage

As stated in the geology section, the dam is built in a narrow valley formed by down cutting of the glacial till by the creek. The dam is founded on both bedrock and glacial till, with the deepest embankment sections founded on the bedrock. The chimney drain is in the area of bedrock foundation from Station 19+00 to about Station 26+75 (Plate 5). At this point it transitions to the glacial till and continues to Station 39+90. Both abutments are glacial till overlying bedrock.

Boring logs indicate that the till has isolated seams of sand and gravel, which was borne out at first filling when a leak developed on the downstream left abutment (Plate 4). A drain system was installed in this area and routed to the irrigation outlet. At the time of our site visit, the estimated flow was 5 gpm (Photo 3). No monitoring of the flow has or is being done. No seepage was noted in the abutment area.

On the right side of the dam, where original ground was incorporated into the embankment, there is a Soil Conservation Service boring, which shows an artesian groundwater condition (Photo 4). The flow is less than 1 gpm. The Soil Conservation Service has drilled several borings around this one in an effort to isolate the cause(s) of the artesian condition. During our visit the water leaving the hole was only very slightly colored and did not appear to be carrying sediment.

The outlet pipe for the internal chimney drain system was below water in the irrigation channel so it could not be inspected.

Our review of the data contained in the as-built drawings, Soil Conservation Service correspondence, and that produced by our field inspections, indicates that foundation treatment and drainage systems should be sufficient to provide protection against uncontrolled abutment, foundation, or embankment seepage.

2.3.3 Stability

The Soil Conservation Service performed numerous stability analyses in the course of embankment design, using strength data taken from consolidated-undrained triaxial tests and a partially drained direct shear test.

Test results are shown below:

Direct Shear Test: $\phi = 20.5^{\circ}$, $C = 100$ psf. Sample remolded at 95% of ASTM D698. Run fast enough for only partial drainage. Classification is sandy to silty clay (CL).

Consolidated Undrained Triaxial: $\phi = 15.5^{\circ}$ to 19.5° . $C = 15$ to 274 psf. Sample remolded to 95% of ASTM D698 and saturated. No pore pressure measurements. Classification is sandy to silty clay (CL).

Consolidated Undrained Triaxial: $\phi = 21.3^{\circ}$ to 23° . $C = 274$ to 1022 psf. Undisturbed (block) samples of silty to sandy clay (CL). No pore pressure measurements.

The Soil Conservation Service analyzed steady state seepage conditions, with and without seismic forces, for the downstream face. Full drawdown and partial drawdown, with and without seismic forces, were analyzed for the upstream face. Soil strength data used in the analyses are summarized below.

Clays: $\phi = 20.5^{\circ}$; $C = 100$ psf.
 Gravel: $\phi = 40^{\circ}$; $C = 0$ psf.
 Bedrock: $\phi = 50^{\circ}$; $C = 6000$ psf.

A tabulation of results follows:

<u>Condition</u>	<u>Factor of Safety</u>	
	<u>SCS Calculated</u>	<u>Inspection Guidelines (Minimum)</u>
Downstream, steady state, no earthquake	1.33	(1.5)
Downstream, steady state, with earthquake	1.1	(1.0)
Upstream, full rapid drawdown, no earthquake	1.01	(1.2)
Upstream, partial rapid drawdown, no earthquake	1.38	(1.2)
Upstream, partial rapid drawdown, with earthquake	1.14	(1.0)

The steady state without earthquake factor of safety for the downstream face does not meet inspection guidelines. Stability safety factors for the upstream, full rapid drawdown condition, without earthquake also does not meet inspection guidelines.

The phreatic surface used in the analyses assumed that the chimney drain was fully effective. Piezometers should be installed to confirm this assumption.

The seismic stability was analyzed during initial design by hand calculations using 0.1 g for an acceleration. Literature searches indicate that the method used yields results comparable to a highly sophisticated computer technique when employed in areas of low to moderate seismicity such as this. We concur with the acceleration that was used.

Numerous sloughs were noted along the reservoir banks. Several of these are 20 to 30 feet in height and are active. At present, they do not pose any problem but may accelerate reservoir siltation in the future.

2.4 PROJECT OPERATIONS AND MAINTENANCE

The project sponsors and Hill County Commissioners have an operations and maintenance agreement with the Soil Conservation Service dated March 16, 1972. That agreement stipulates among other things that a reservoir management plan be developed to ensure that project purposes are fully accomplished. In accordance with this agreement, a reservoir operation and management agreement was entered into by the Hill County Commissioners and the Soil Conservation Service on December 19, 1974. A "Reservoir Operation Manual" was developed in February, 1975. It provides the basis for reservoir management. (Ref. 9).

2.4.1 Dam

Annual operations and maintenance inspections have been made by the sponsors with assistance from the Soil Conservation Service, since the dam was completed. As a result maintenance has been good, with problem areas identified and treated on a timely basis. Daily visits by the Reservoir Manager before, during, and after the irrigation season ensures that all hydraulic structures are functioning properly.

2.4.2 Reservoir

The aforementioned Reservoir Operation Manual is utilized in reservoir management. Basic data is obtained on snow pack, precipitation, soil moisture, and temperature. Locations of the data collection sites are shown on Plate 3. In general, forecasts are given in volume amounts of runoff to be expected during the snowmelt period, with adjustments made for rainfall runoff as it may occur. The Reservoir Manager, Mr. Windecker, is gaining practical experience and understanding of inflow-outflow conditions required to manage reservoir levels on a daily basis to prevent large spillway flows.

2.4.3 Warning Plan

There is no formal warning plan for use in the event of impending dam failure.

CHAPTER 3 FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of engineering data and as-built plans, for the project in terms of the Recommended Guidelines (Ref. 1) resulted in the following findings:

3.1.1 Size, Hazard Classification and Safety Evaluation

The 108-foot high dam impounds about 8700 acre-feet of water with the reservoir at dam crest. In accordance with inspection guidelines, Beaver Creek Reservoir Dam is large in size and based on our visual inspection and judgment, it has a high downstream hazard potential. Therefore, the guideline's recommended spillway design flood (SDF) for this project is 100 percent of the PMF. Based on reconnaissance level investigations, and routing of the estimated PMF developed for this study, the project can control a flood equal to about 19% of the PMF hydrograph ordinates. Because the project can not safely handle $\frac{1}{2}$ the PMF it is considered unsafe (non-emergency) until recommended actions are completed.

Examination of hazard potential rating and hydraulic criteria used by SCS in original proportioning of storage and discharge capacity shows that the dam was classified as having moderate (significant) downstream hazard potential. The spillway design flood developed by SCS considered the PMP as occurring on the entire 79 square miles contributing drainage area. No consideration was given to possible overtopping and breach of Bearpaw Lake Dam in the routing of the spillway design flood. More detailed hydrologic and hydraulic routing studies are needed to better determine the downstream hazard and required spillway capacity.

3.1.2 Spillways

a. Principal Spillway

Visual inspection of the reinforced concrete chute spillway showed that in general its condition is excellent. There is no evidence of serious settlement or cracking of concrete exceeding design articulation of joints. Concrete surfaces appear hard and durable. A slope drain of the east side of the spillway through the side wall has broken at the outside face of the wall. There is minor cracking of floor slabs in chute sections. Both of these items were observed in the 1978 Operations and Maintenance Report prepared jointly by Owners and the Soil Conservation Service. The Soil Conservation Service's engineers are following-up with design of repairs for the broken drain pipe and are observing cracks in floor slabs for evidence of further separation. There is no evidence of deep scour that would threaten to undermine the stilling basin. Some lateral erosion would be expected to occur downstream from the stilling basin during prolonged periods of high flows. Clogging of the spillway with debris is considered unlikely as the entrance is protected with a log boom. Preliminary computations show that the maximum discharge of 2030 c.f.s. is just contained in the chute spillway.

b. Emergency Spillway

The earth emergency spillway around the right abutment is well vegetated. There is no evidence of flows having occurred in the spillway. Records of reservoir elevations attained since the dam was completed show

a maximum water surface elevation of 3095.3 feet MSL which is 2.2 feet below emergency spillway crest at 3097.5 feet MSL.

It is anticipated that flows in the emergency spillway will be very infrequent, however, should high flows occur for a short period of time, erosion would be expected to occur in the outlet channel downstream from the control section. Because of bulk length provided by 330-foot level section, breaching of the emergency spillway is considered unlikely.

3.1.3 Outlet Works

The irrigation outlet works was functioning at the time of visit. Since it was impractical to disrupt irrigation deliveries, an inspection of the inside of the 30-inch diameter irrigation outlet was not made. Visual inspection of the top of concrete pressure chamber and steel plate cover on the manhole revealed minor cracks in concrete radiating from the cover opening (Photo 10). The impact basin at outlet was functioning as designed to reduce velocities at outlet, and appears to be in good condition. The guardian gate at inlet to the irrigation pipe on the upstream side of dam has a slow leak in the hydraulic system which allows the gate to close by itself. Mr. Windecker stated that it was necessary to raise the gate every 10 to 15 days to ensure full delivery of irrigation and reservoir management flows. Steps are being taken to place positive shut-off valves in hydraulic lines to prevent slow gate closure. Gates housed in the outlet pressure chamber are well sealed and no difficulty in operation was reported by Mr. Windecker.

3.1.4 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 185 acres and a storage of 6270 acre-feet at principal spillway crest elevation 3091.5 feet MSL. Approximately 2430 acre-feet of surcharge storage is available between the principal spillway crest and dam crest elevation 3102.5 feet MSL. The discharge capacity of the uncontrolled principal (chute) spillway, with the reservoir at emergency spillway crest elevation 3097.5 feet MSL is approximately 2030 c.f.s. The combined capacity of the two spillways is 17,280 c.f.s. with reservoir at top of dam. The low level/irrigation outlet has a capacity of approximately 135 c.f.s. with reservoir at principal spillway crest elevation 3091.5 feet MSL.

3.1.5 Embankment Dam

Visual inspection of Beaver Creek Reservoir Dam revealed no visible sign of unusual settlements, cracking, bulging, or depressions which would indicate distress. There is some minor rill erosion on the downstream slope and in the groin area of the right abutment. The downstream slope is well protected with heavy vegetation. Recent photos (May, 1980) show evidence of vehicular traffic on the downstream slope. This practice should be prohibited.

Riprap on the upstream slope appears to be providing adequate protection, however some deterioration of larger size rocks was noted, presumably due to freeze-thaw.

3.1.6 Geotechnics - Site Geology

The dam is founded on both bedrock and glacial till, with the deepest embankment founded on the bedrock. The combination embankment (chim-

ney) and foundation drain appears to be functioning adequately, since no damaging seepage was noted on the downstream slopes or at the toe of the dam. After construction and at first filling a seep developed on the downstream left abutment. A collector and drain system was installed and routed to the irrigation outlet channel. No piezometers have been installed in the embankment or foundation to monitor phreatic surfaces. An artesian condition was observed in an SCS boring on the downstream right side of the dam. There is no evidence of movement of soil materials in the artesian flow estimated at less than 1 g.p.m.

Our review of engineering data, "as-built" drawings, Soil Conservation Service reports, and that produced by our field inspections, indicates that foundation treatment and drainage systems appear to be adequately controlling abutment, foundation and embankment seepage.

3.1.7 Stability

A review of stability analyses performed by SCS during design of the embankment showed that satisfactory factors of safety were obtained for all conditions examined in accordance with SCS design criteria then in effect. However, the static factor of safety for downstream, steady state seepage and no earthquake, and the upstream, full rapid drawdown, without earthquake condition do not meet recommended guidelines criteria. The phreatic surface used in the analyses assumed that the chimney drain was fully effective. Piezometers should be installed to confirm this assumption.

3.1.8 Operations and Maintenance

A reservoir operations manual has been developed by the Hill County Commissioners with assistance from the U.S.D.A. Soil Conservation Service and has been effectively utilized for the past four years to manage the reservoir. (Ref. 9). The outlet works does not have sufficient capacity to enable precise reservoir management if spring rains increase inflows to over 300 c.f.s. for prolonged periods of time (20+ days). However, flows of 400 to 600 c.f.s. are easily and safely handled by the concrete chute spillway. Experience data gathered from year to year is being used to refine forecast accuracy, according to Phil Farnes, Snow Survey Supervisor and Hydrologist for the Soil Conservation Service in Montana.

An annual inspection of the project facilities is conducted. During the operating season the dam is visited almost daily by the resident reservoir manager, Mr. Claude Windecker. Critical maintenance needs affecting structural integrity have been promptly taken care of. The road on the dam crest is well maintained.

3.2 RECOMMENDATIONS

Due to storage between principal spillway crest and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of this report recommendation is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Develop and implement an emergency warning plan for use in the event of impending overtopping with flood waters and/or possible dam failure. It is imperative that the warning plan be coordinated with the emergency warning plan implemented for Bearpaw Lake Dam and East Fork Dam upstream on the Beaver Creek Drainage.

2. Inspect inside of pressure chamber housing gates, irrigation outlet conduit, and low level outlet conduit and intake. Repair as required.
3. Repair erosion rills on downstream slope and groin area of downstream right abutment by filling, compacting, and seeding or sodding.
4. Continue to monitor artesian condition in the Soil Conservation Service boring.
5. Repair broken slope drain at east wall of chute spillway.
6. Repair or modify hydraulic lift and valves on upstream gate to prevent slippage.
7. Inspect stilling basin floor and end sill.
8. Prohibit/protect against vehicular traffic on the downstream slope of the dam.
8. Install piezometers and monitor to accurately determine the effectiveness of the chimney drain and pore pressure distributions within the embankment. Use this data to update existing stability analysis and modify dam if indicated.
10. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard, the potential hazard posed by possible breach failure of Bearpaw Lake Dam, the recommended spillway design flood, and required spillway capacity. Modify the project as studies indicate.
11. Conduct inspections of Beaver Creek Reservoir Dam at least every 5 years by qualified engineers experienced in earth dam design, construction, operation and maintenance.

Prior to performing engineering studies and possible remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C.; Department of the Army, May 1975.
2. Hill County Soil and Water Conservation District et. al., Watershed Work Plan Beaver Creek, Hill County, Montana, Sept. 1967.
3. U.S. Corps of Engineers, HEC-1 Flood Hydrograph Package Dam Safety Investigations, Davis CA, Sept. 1978.
4. U.S. Weather Bureau, Technical Paper No. 38 - Generalized Estimates of Probable Maximum Precipitation for United States West of 105 Meridian, 1960.
5. U.S. Weather Bureau, Hydrometeorological Report No. 43 - Probable Maximum Precipitation Northwest United States, November, 1966.
6. Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, 1972.
7. U.S. Bureau of Reclamation, Design of Small Dams, Second Ed. 1974.
8. U.S. Soil Conservation Service, Hydrology of Beaver Creek, Havre, MT. In house report, Bozeman Office, 1967.
9. U.S. Soil Conservation Service, Reservoir Operational Manual For Beaver Creek Watershed, February, 1975.

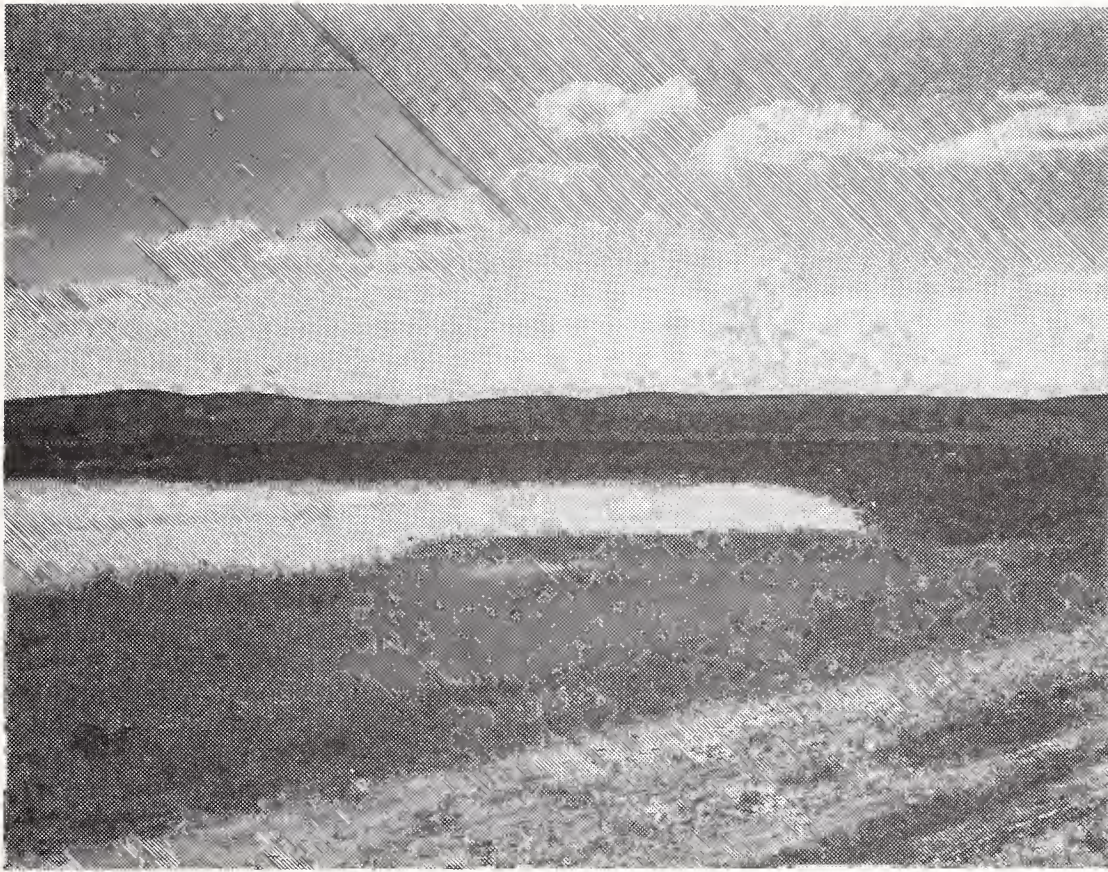


PHOTO 1 - General Upstream Slope.
Principal spillway entrance at left.



PHOTO 2 - Erosion rill on downstream slope-
Note dense vegetation.



PHOTO 3 - Outlet for drain from
left abutment

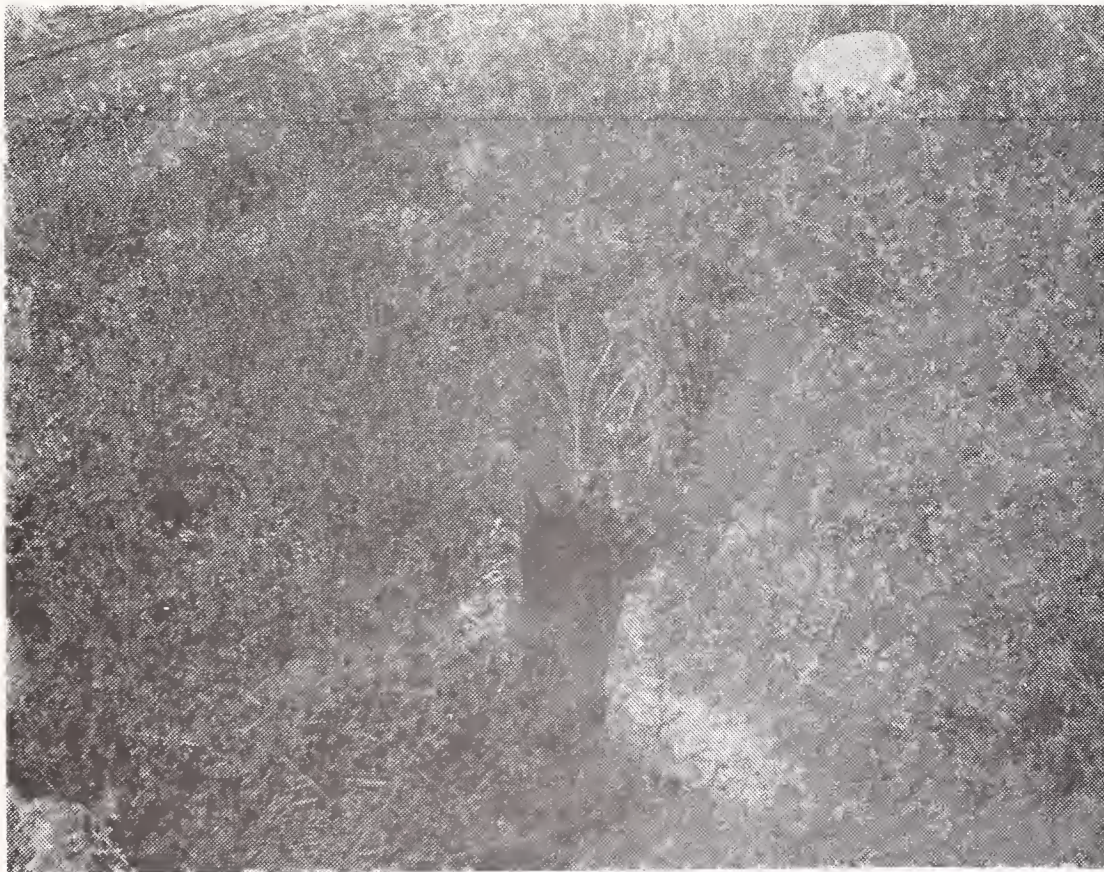


PHOTO 4 - SCS Boring under artesian head.



PHOTO 5 - Joint separation of chute walls.
(Within design allowances)

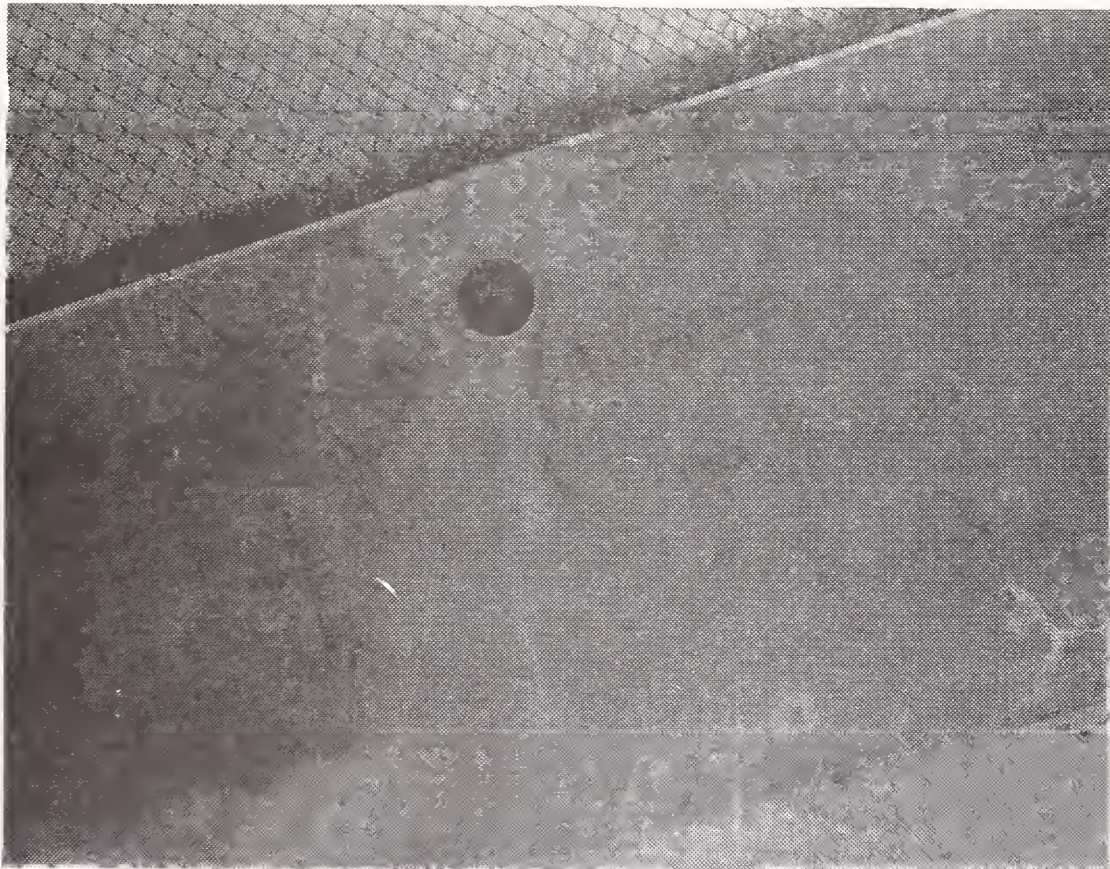


PHOTO 6 - Drain pipe broken (sheared)
behind spillway wall.

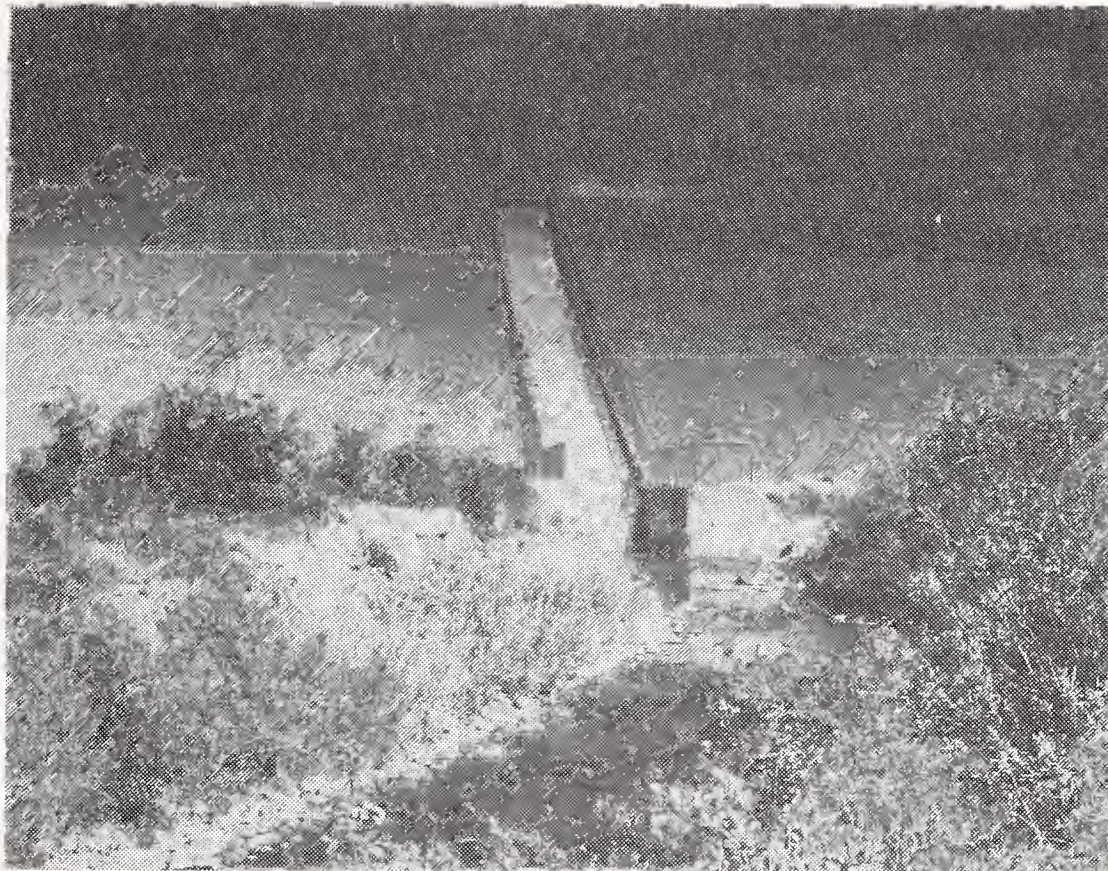


PHOTO 7 - Chute spillway. Water is coming from irrigation outlet to right looking upstream.

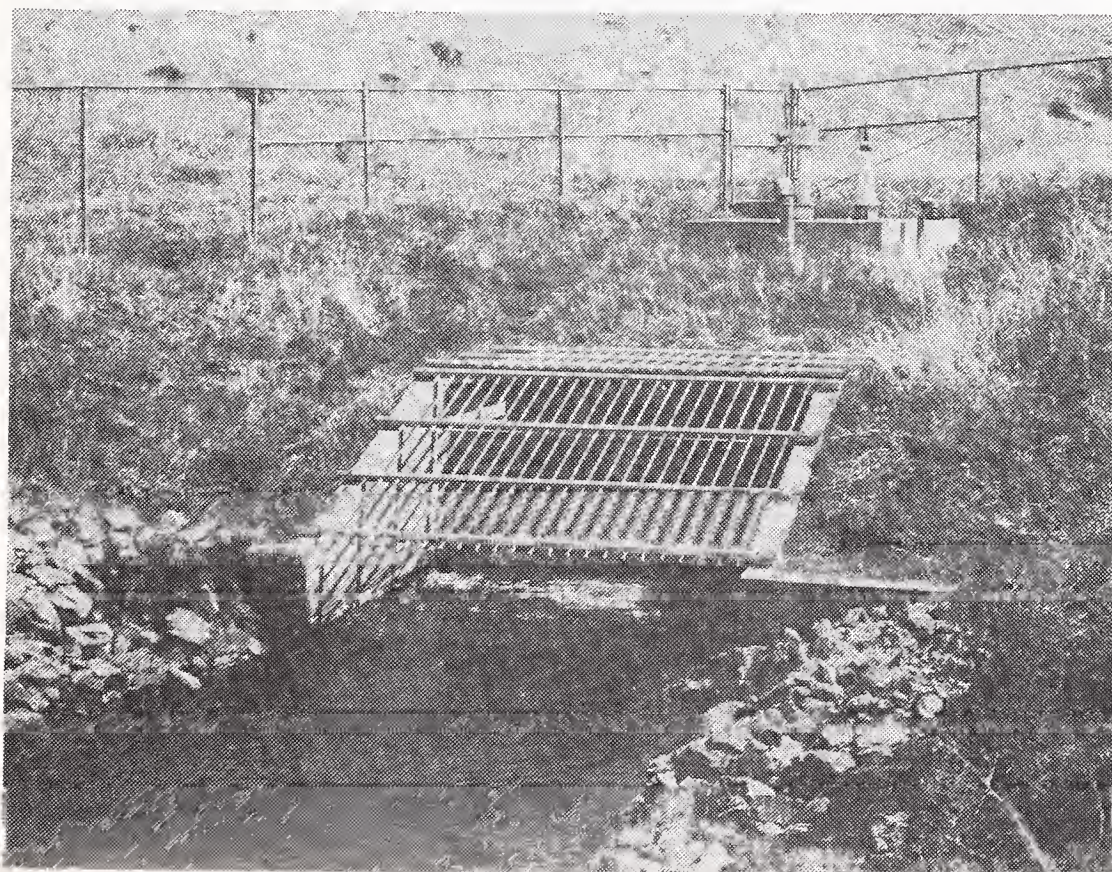


PHOTO 8 - Irrigation outlet. Pressure chamber & gate controls upper right.



PHOTO 9 - Approximately 600 ft. downstream from spillway outlet. Note meander development

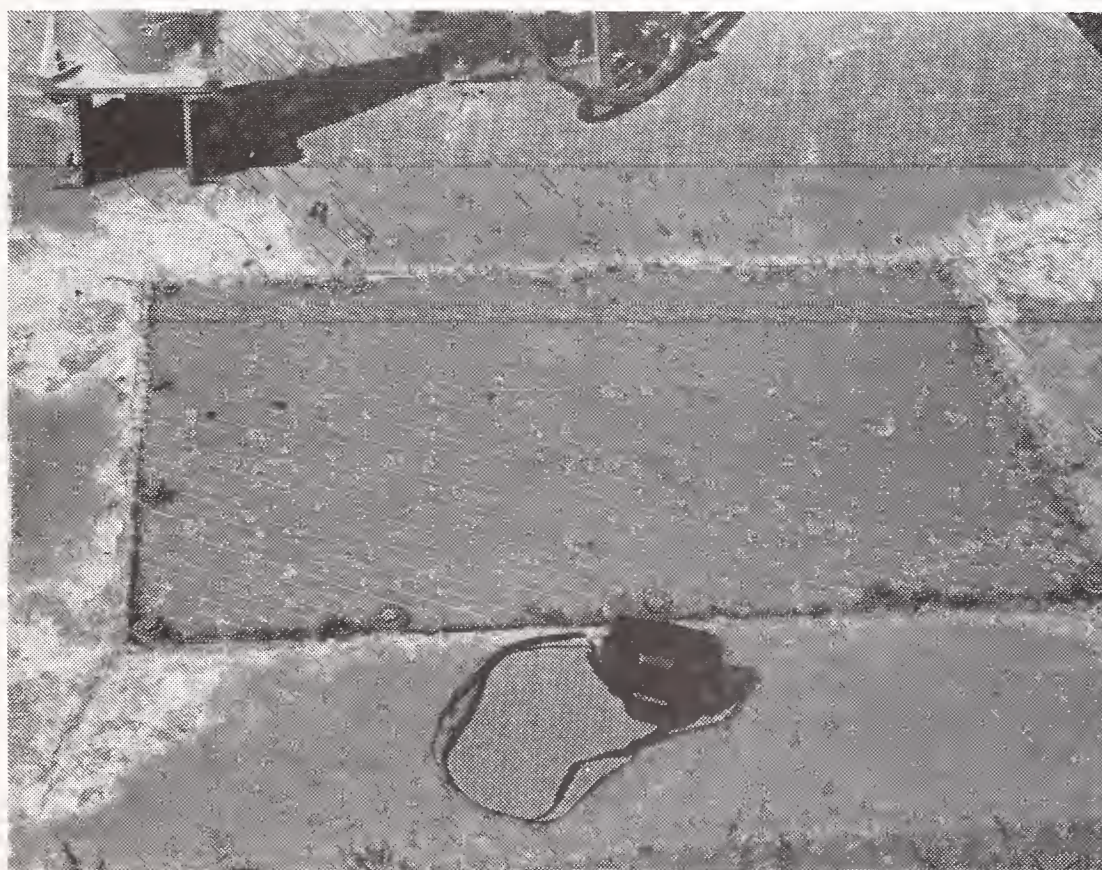


PHOTO 10 - Top of pressure chamber. Minor cracking concrete radiating from pressure manhole.



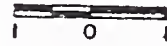
PLATE 1
VICINITY MAP

MILK
RIVER

HAVRE

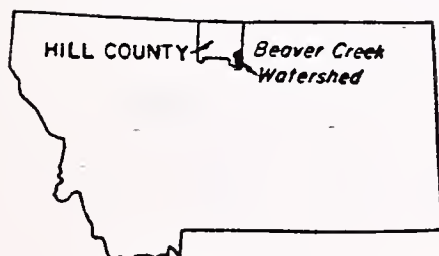
BEAVER CREEK WATERSHED

HILL COUNTY, MONT.



BEAVER CREEK
RESERVOIR

BEARPAW LAKE



LOCATION MAP

EAST FORK
DAM

PLATE 2
BEAVER CREEK
DRAINAGE

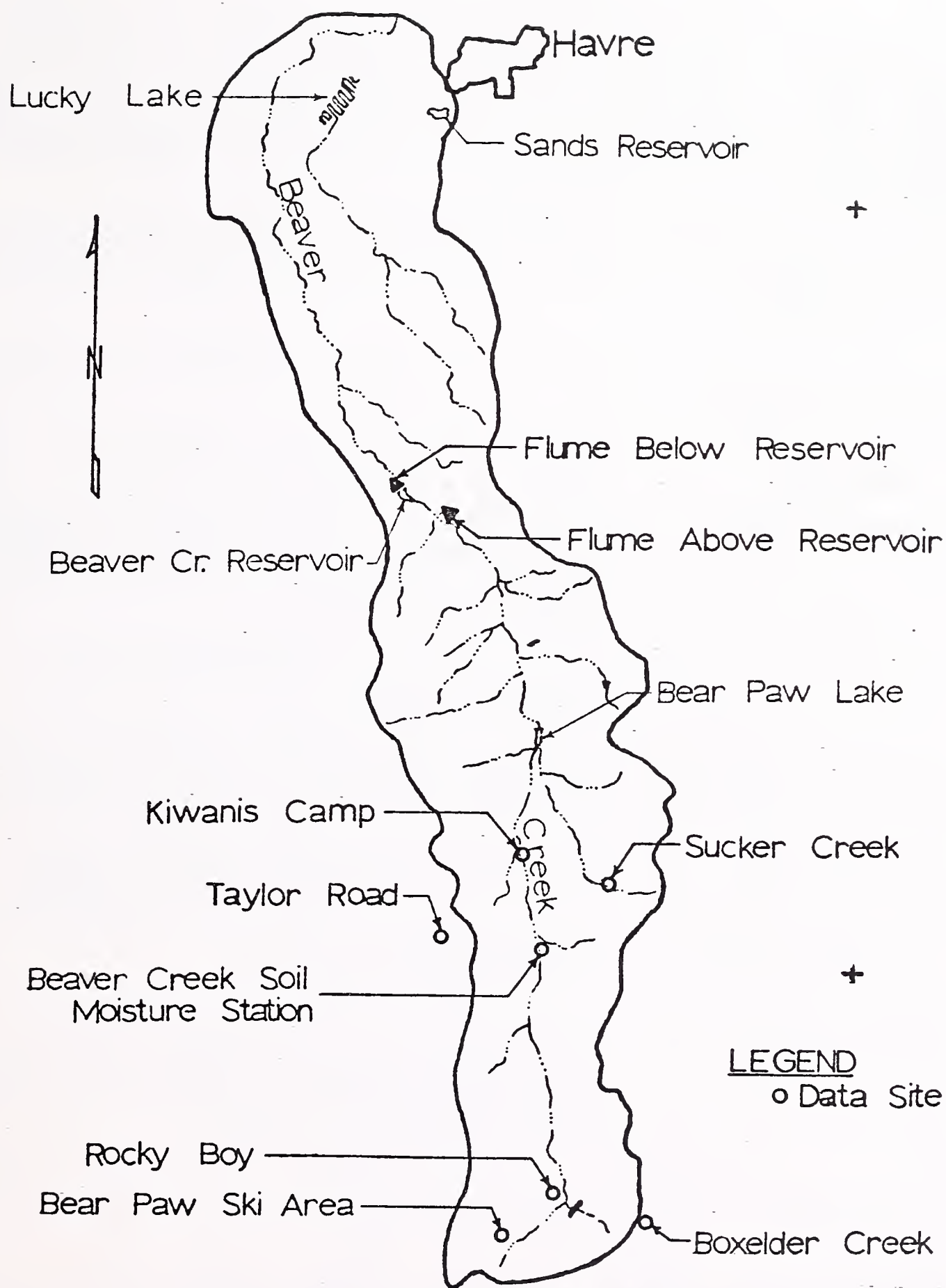


PLATE 3
BEAVER CREEK WATERSHED

SCALE: 0 5mi.

BASIC DATA OBSERVATIONS AND SITES

An integral and important part of reservoir operation is collection of basic data to document correlation between various climatic and runoff events. The designated Reservoir Manager, Havre Soil Conservation Service field office, and Soil Conservation Service Snow Survey Supervisor will work together to obtain accurate and timely basic data necessary for the proper operation of the Beaver Creek Reservoir.

There are six data sites in the Beaver Creek watershed where information on precipitation, snowfall, snowpack, temperature, soil moisture, and wind travel are obtained. A map of these data sites is included in this Appendix.

A tabulation of data collected at each site, frequency of reading and site name follows:

<u>Site Name</u>	<u>Climatic data obtained and frequency</u>
Kiwanis Camp	- Precipitation - daily; maximum and minimum air temperature - daily; snowfall - daily; snow water equivalent - monthly Jan-May; wind travel - daily.
Beaver Creek S. M.	- Soil moisture and soil temperature are obtained monthly.
Sucker Creek	- Precipitation - monthly; snowfall - daily; snow water equivalent - monthly Jan-May.
Taylor Road	- Precipitation - monthly; snowfall - daily; snow water equivalent - monthly Jan-May.
Boxelder Creek	- Precipitation - monthly; snow water equivalent - monthly Jan-May.
Rocky Boy	- Precipitation - monthly; snowfall - daily from snow pillow; snow water equivalent - daily from snow pillow; temperature - daily from thermograph; soil moisture - monthly; soil temperature - monthly.
Bear Paw Ski Area	- Precipitation - monthly; snow water equivalent - monthly Jan-May.

A monthly summary will be maintained showing basic data obtained at each of the above sites. Copies will be maintained by both the Reservoir Manager and the Service's Representative. Charts, daily observations, etc., will be maintained by Soil Conservation Service.

As more data is obtained from these locations, it may be possible to reduce the number of sites if there is a strong correlation of precipitation or snowfall between some of the sites.

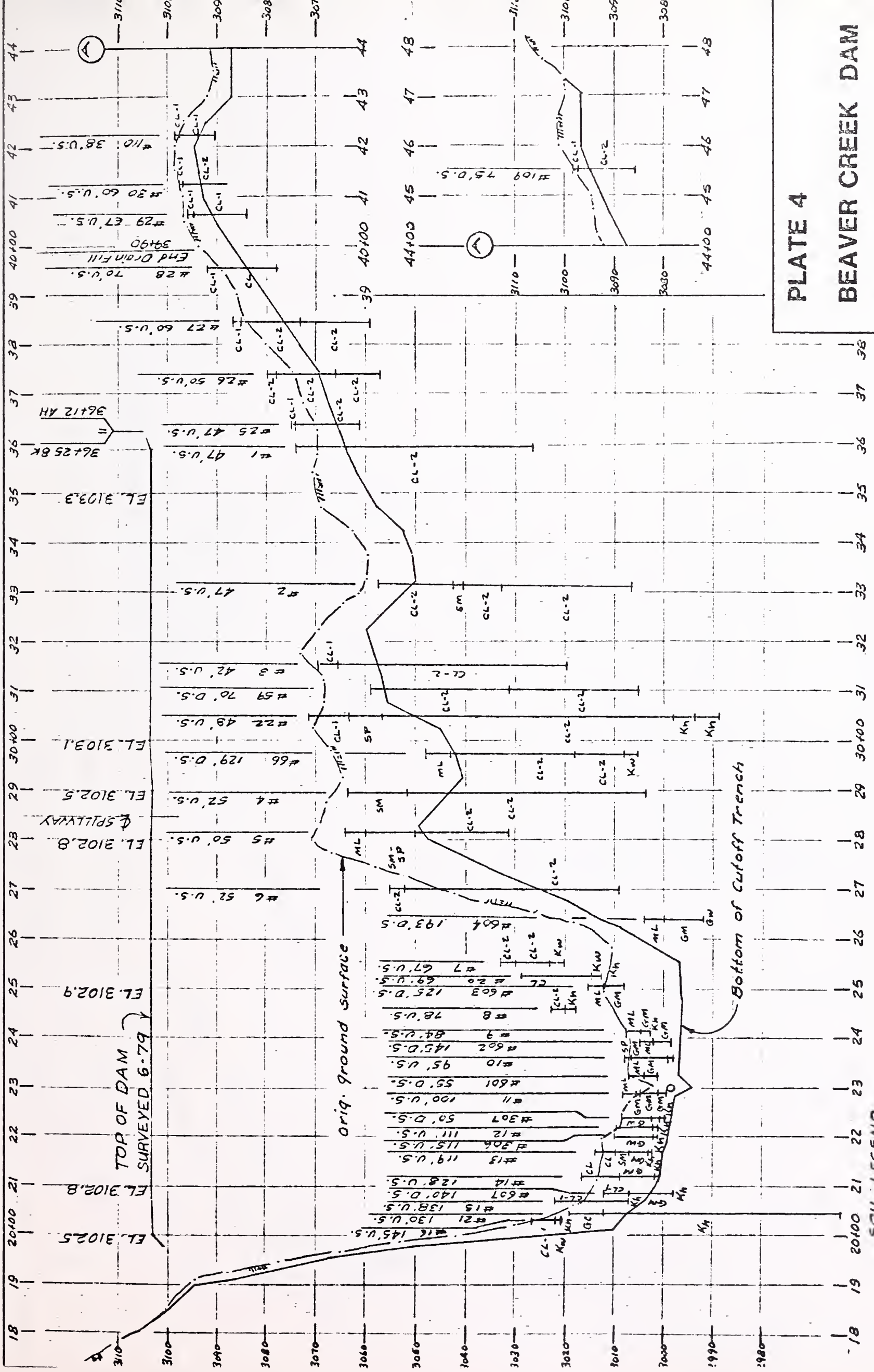


PLATE 4

BEAVER CREEK DAM

GEOLOGIC

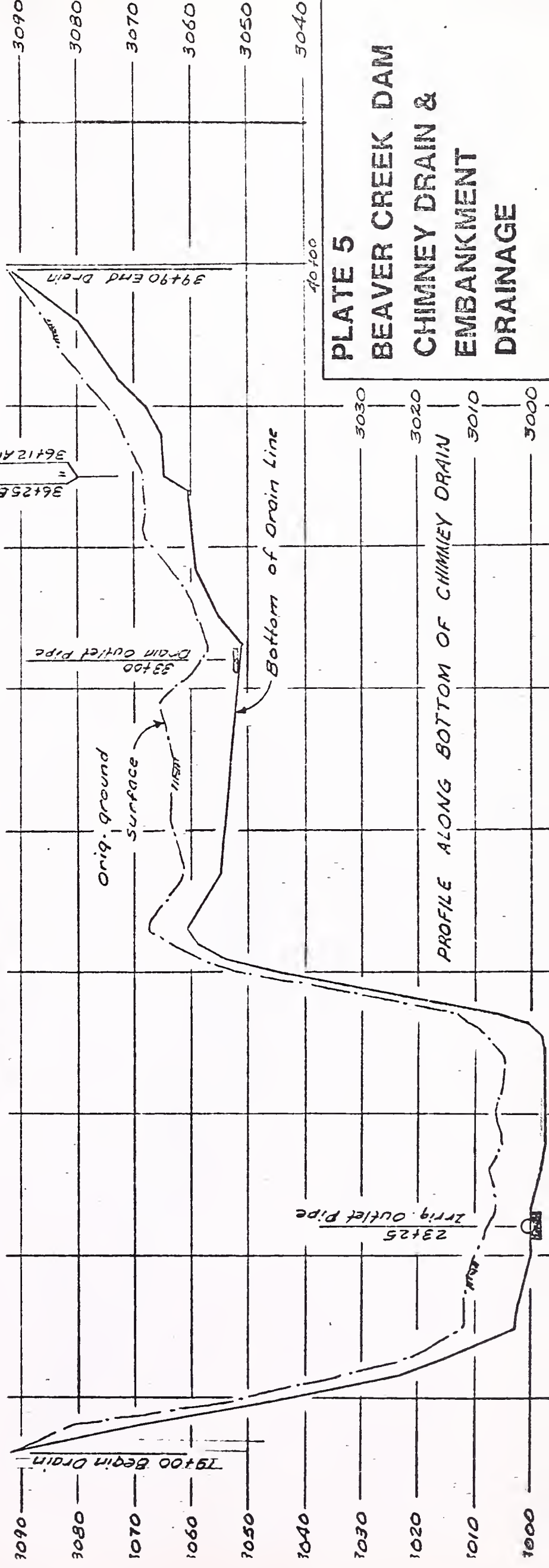
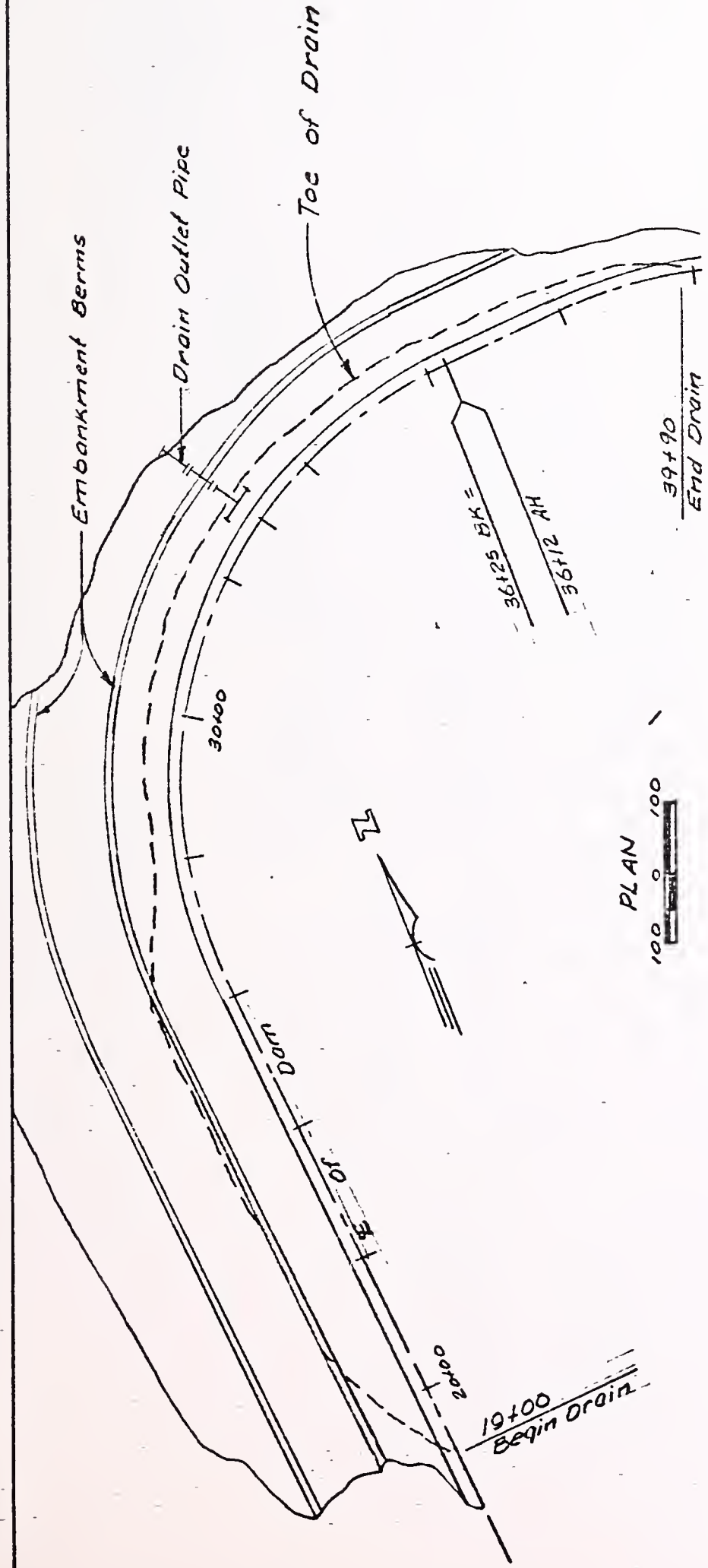
SECTION

PROFILE ALONG C OF DAM

SOIL LEGEND

- CL - CLAY
- ML - SILT
- SP - SAND
- GC - GRAVELLY CLAY
- GM - SILTY GRAVEL
- SC - SANDY CLAY
- SM - SILTY SAND
- GW - GRAVEL
- MN - PLASTIC SILT
- KH - BED ROCK
- KW - WEATHERED BED ROCK

PLATE 5 BEAVER CREEK DAM CHIMNEY DRAIN & EMBANKMENT DRAINAGE



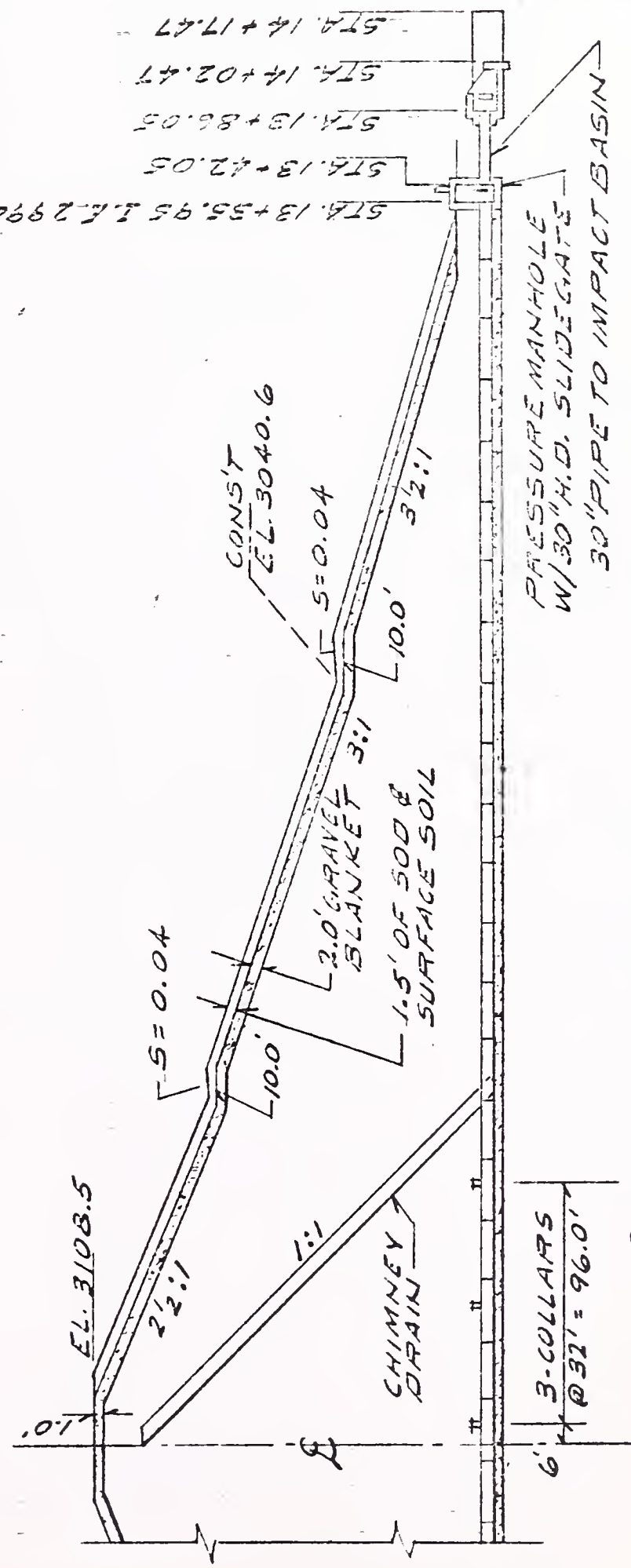
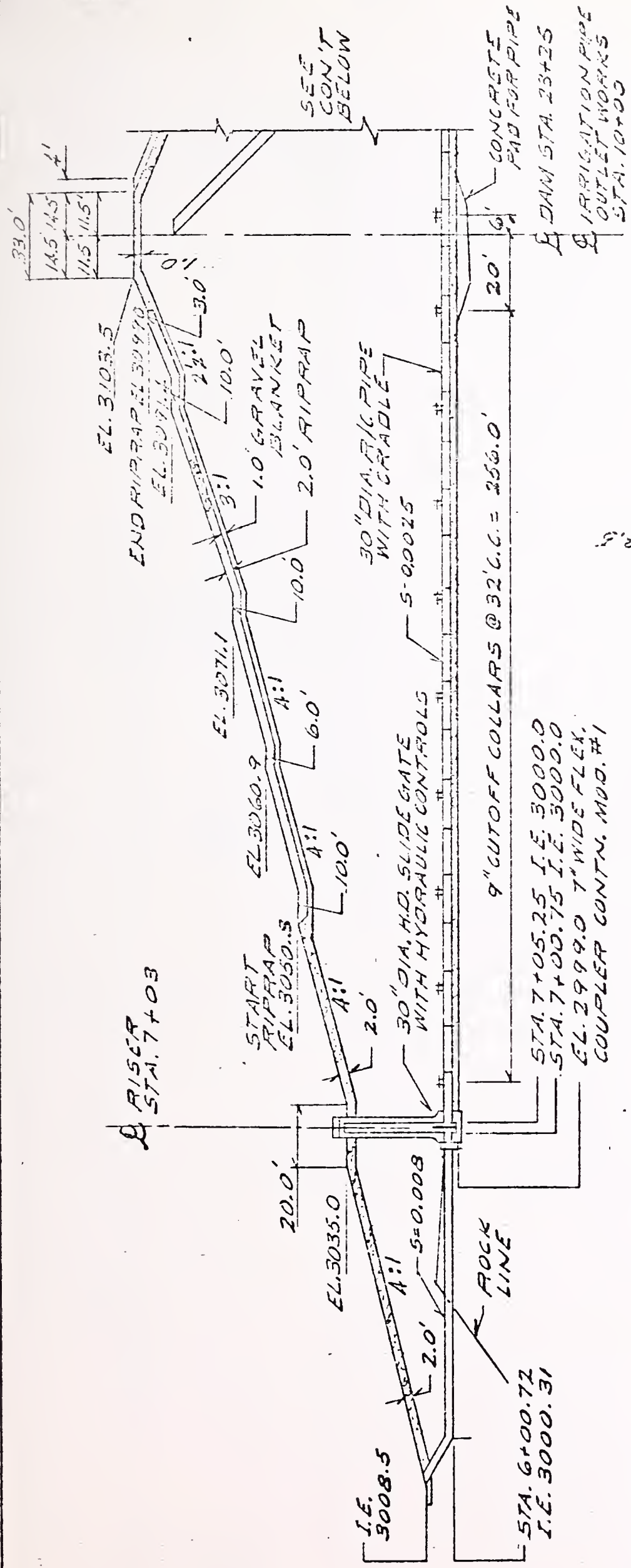


PLATE 6

BEAVER CREEK DAM

OUTLET CONDUIT &

DAM EMBANKMENT

PROFILE OF IRRIGATION OUTLET WORKS

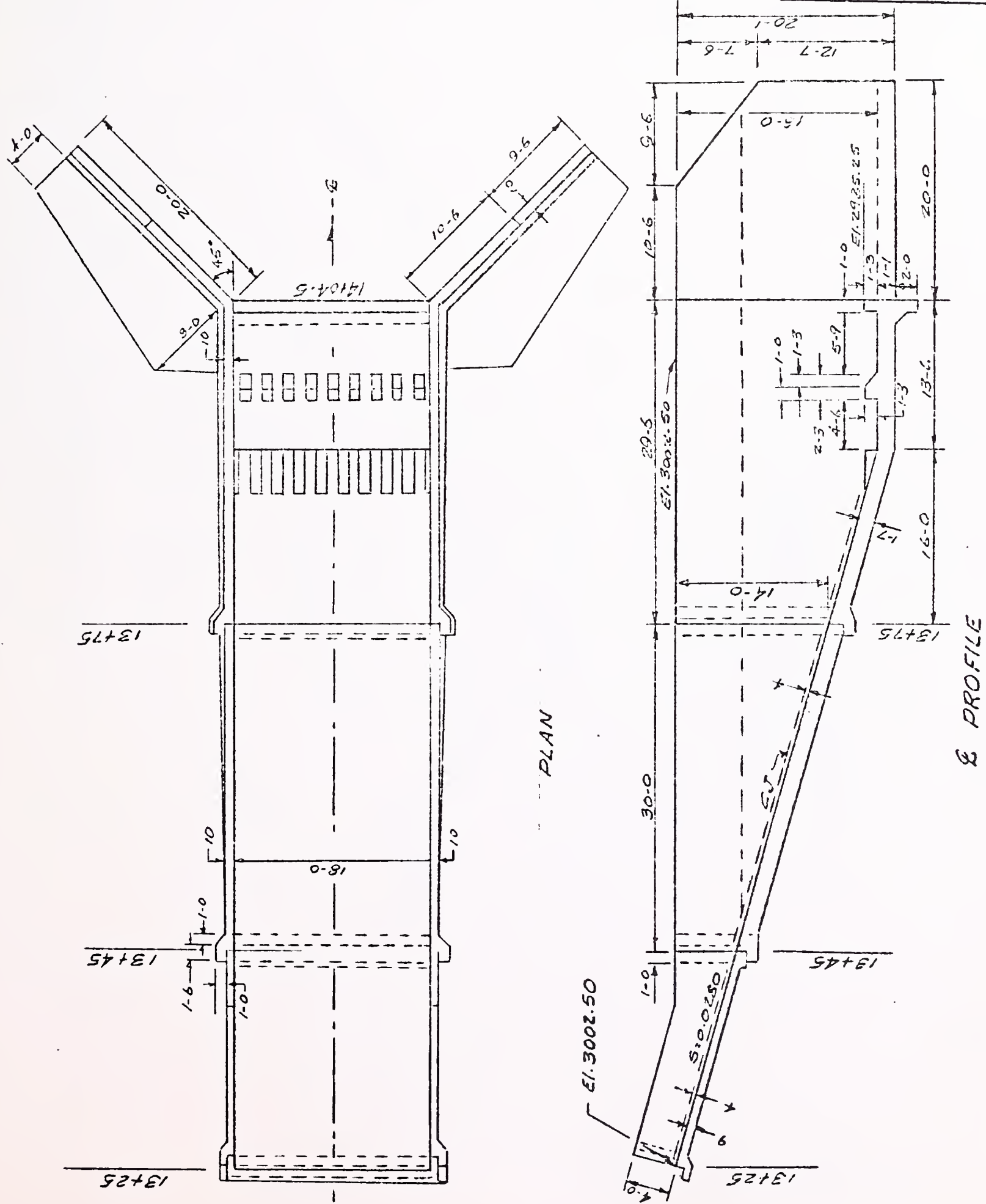
NOT TO SCALE

PLATE 7-B

BEAVER CREEK DAM

PRINCIPAL SPILLWAY

PLAN & PROFILE



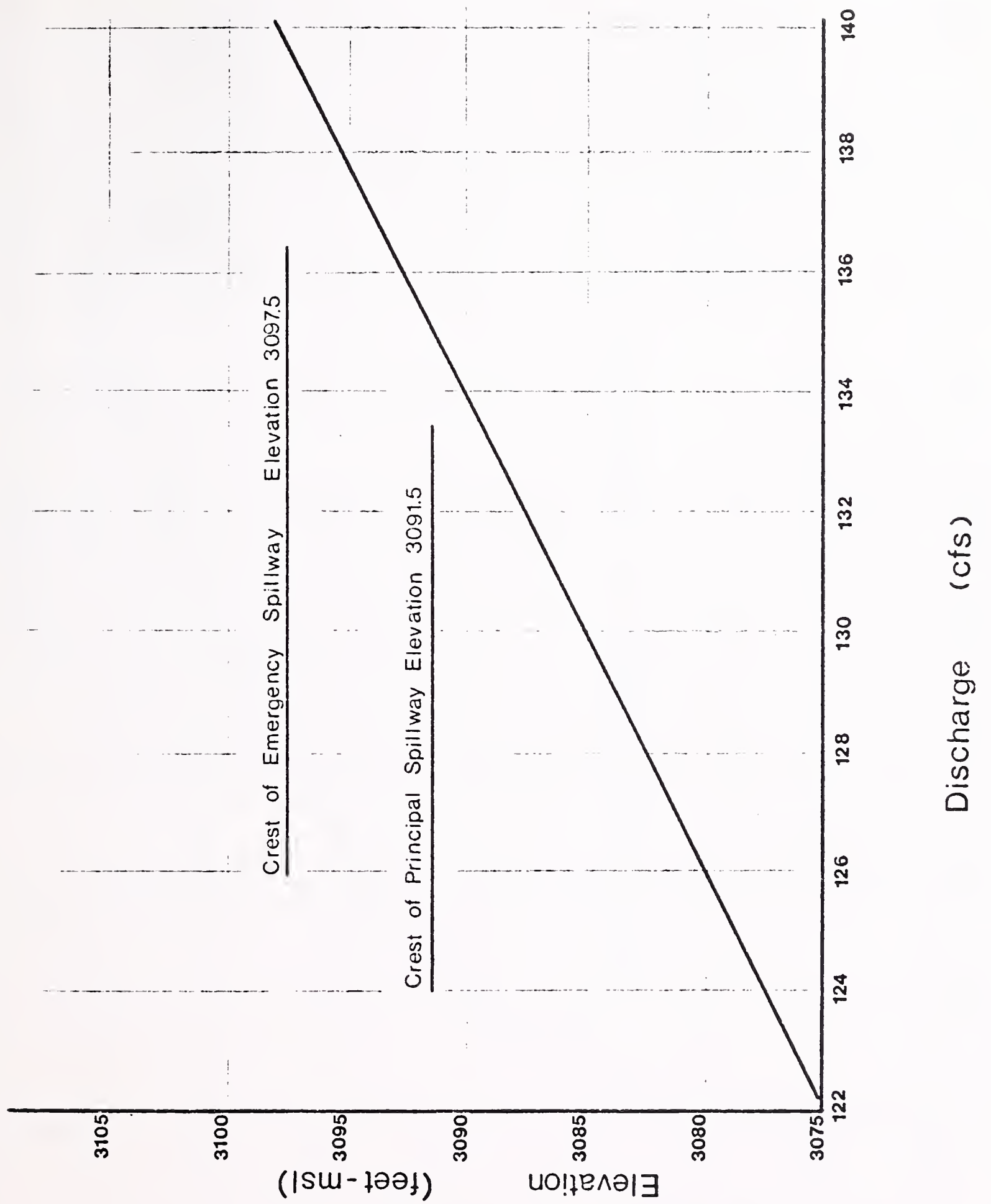


PLATE 9

BEAVER CREEK DAM

OUTLET WORKS

DISCHARGE RATING

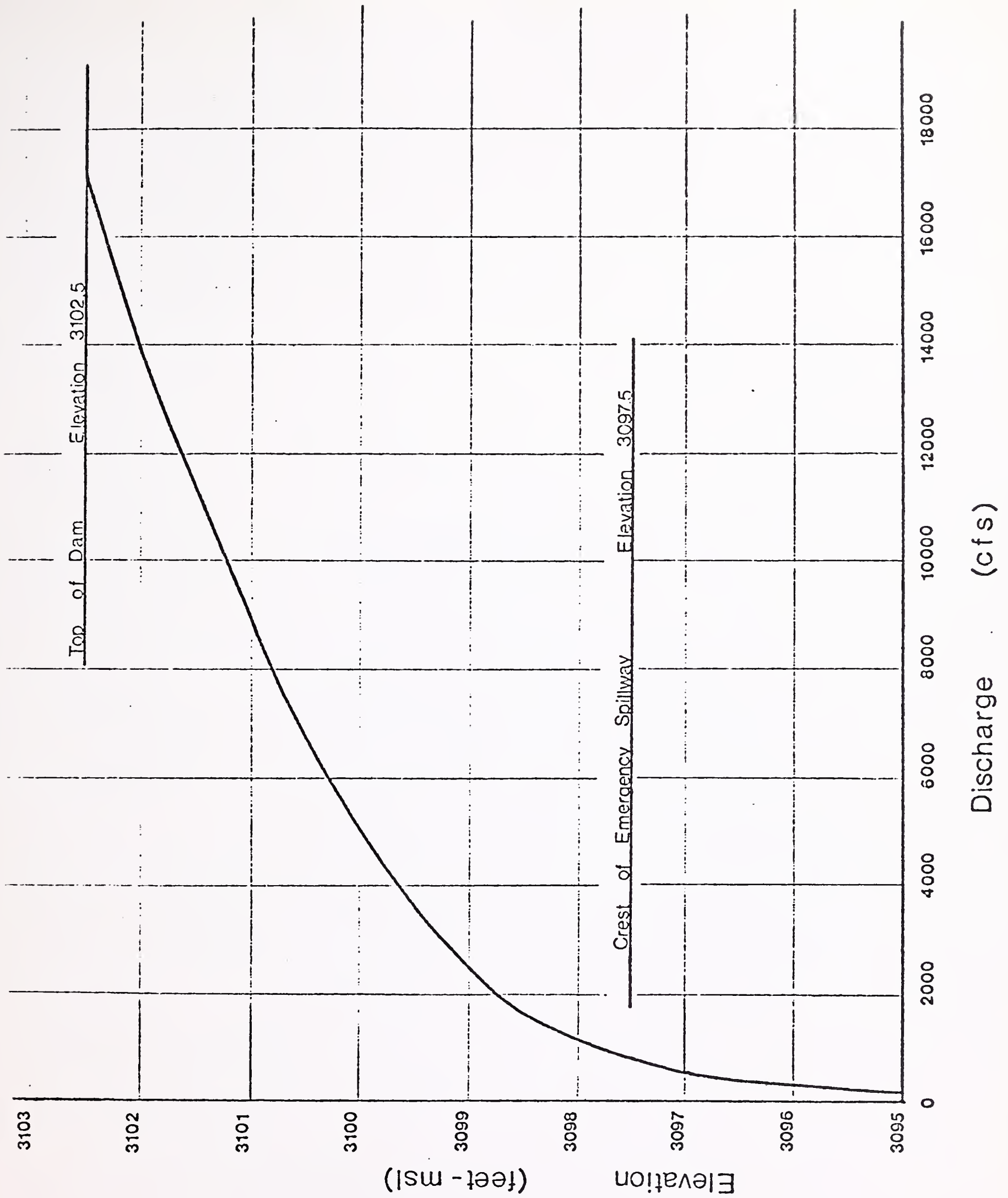


PLATE 10

BEAVER CREEK DAM

COMBINED SPILLWAY

DISCHARGE RATING

APPENDIX A



United States
Department of
Agriculture

Soil
Conservation
Service

P.O. Box 970
Bozeman, MT
59715

December 19, 1980

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on the Beaver Creek Reservoir Dam (MT-510).

Our comments relating to specific report statements are:

Page 19, line 7; Construction records available in the Bozeman SCS state office state that 109 permeability tests and 84 gradation tests of the drain fill material were made during excavation and placement.

Page 19, paragraph 2; There is a record of 542 in-place density tests available for review in the Bozeman SCS state office.

Page 22 and 23: We suggest that one term consistently used for "dynamic", "earthquake", and "seismic" will avoid possible confusion.

Page 23: The SCS calculated factors of safety meet SCS minimum criteria.

We do not agree with the hydrologic conditions used to develop the probable maximum flood. The conditions selected attempt to eliminate the element of risk to a degree that we feel is not practical or reasonable. Despite the climatic differences, the Omaha District appears to be imposing much more reasonable hydrologic conditions than is the Seattle District. We suggest that a common degree of risk (probability) be applied by the COE nationwide.

Sincerely,

for Van K Haderlie
State Conservationist

cc:

Ray Smith, Acting State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman



The Soil Conservation Service
is an agency of the
Department of Agriculture

SCS-AS-1
10-79

Beaver Creek Reservoir Dam Comment:

Having lived on Beaver Creek at Northern Research Center it seems the comment on overflow of Beaver Creek Dam is almost impossible. The greatest risk would appear to be failure of East Fork Dam on Rocky Boy's Reservation as spillway would appear to be inadequate. The greatest flow in this time with several years with Maximum Peak in June estimated flow about 300 sec ft with a Maximum in 1974 of probably 500 sec ft. Safety will depend on safety of Bear Paw Lake and East Fork Lake.

Claude Windesher
Reservoir Manager



Visit
MONTANA
the BIG SKY Country

BOARD OF COUNTY COMMISSIONERS
HILL COUNTY
HAVRE, MONTANA

CHAIRMAN

COMMISSIONER

COMMISSIONER

Daniel Morse

Arthur Rambo

A. R. Hagener

5 February, 1981

Sidney Knutson, P. E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P. O. Box C3755
Seattle, Washington 98124

RE: Phase I - Inspection Report
National Dam Safety - Beaver
Creek Reservoir Dam

Dear Mr. Knutson:

Please find enclosed the comments from our Lower Beaver Creek Dam Reservoir Manager, Mr. Claude Windecker, pertinent to the above referenced project. Also be advised that the Hill County Park Board met this past Monday evening and discussed the report as issued. The Park Board, as well as this Board, feel that Mr. Windecker expresses our feelings and opinions accurately on this matter.

We have spent the greater portion of our life in this area and have never experienced the type of flow indicated, and therefore find the report to be highly unrealistic. The Soil Conservation Service, as well as our own Reservoir Manager and Park Superintendent, are continually inspecting the dam structure and monitoring the stream flows and have done so for a number of years. We feel that we must give credit to their experience and knowledge which has been gained over a long period of time and weight it in perspective to a short-term study.

The Dam is inspected at various times each year for maintenance problems and is repaired and maintained according to the inspections. We believe the dam to be a sound structure.

Thank you for this opportunity to comment.

Sincerely yours,

Dan Morse
Daniel Morse, Chairman

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION



THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

January 22, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Beaver Creek Reservoir Dam (MT-3207). We concur with the findings and recommendations in the report and feel that the report satisfies the criteria for the Phase I investigation. Our comments have been discussed with your staff and we understand that they will be incorporated into the final report.

Thank you for the opportunity to review and comment on the final report for this project.

Sincerely,

A handwritten signature in cursive script that reads "Richard L. Bondy".

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:lj

